CAHNERS PUBLICATION
INTERNATIONAL EDITION
SEPTEMBER 17, 1987

6 NOV 1987

EDN®

32-bit-CPU board directory

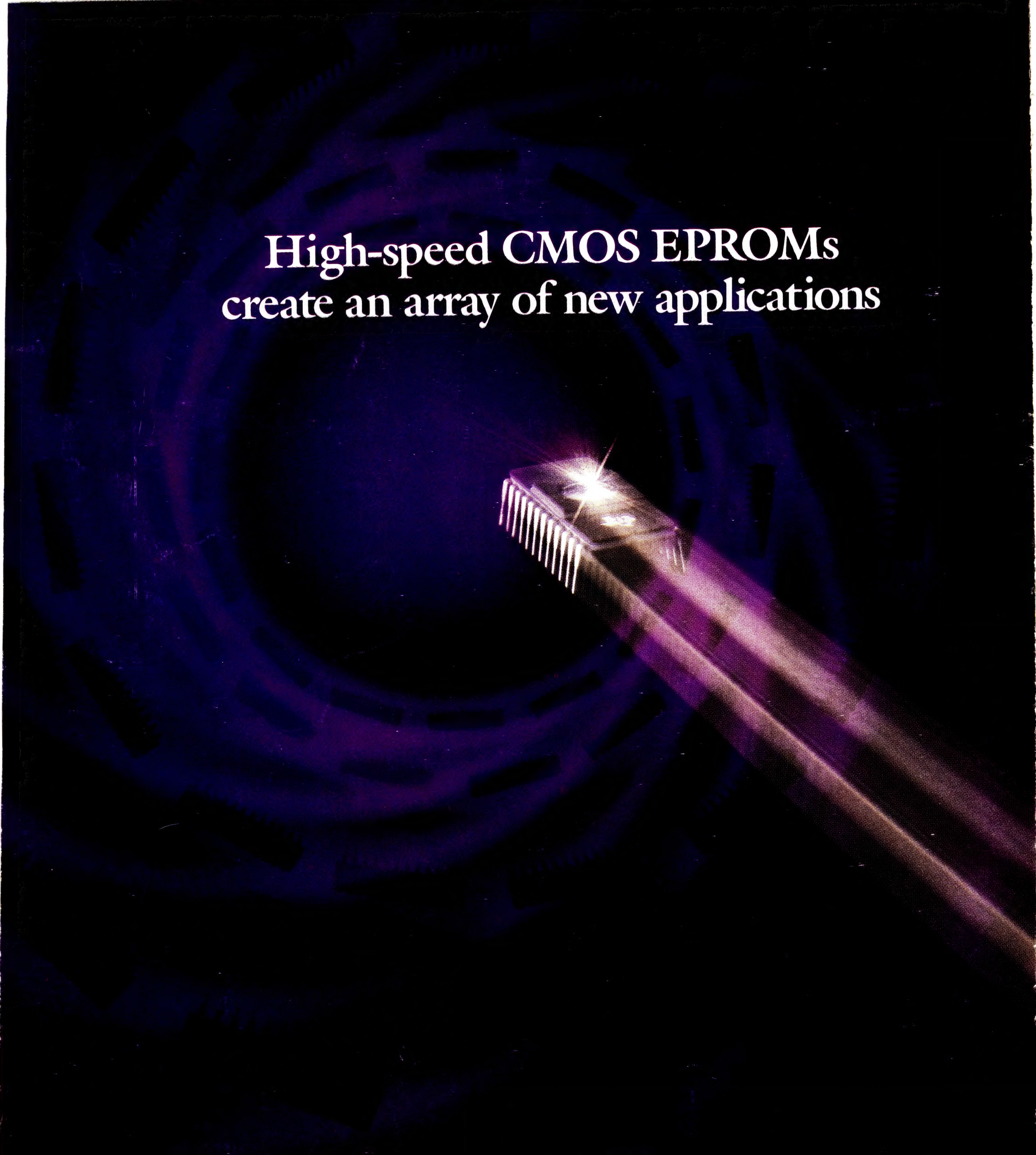
Minimize phase error with matched op amps

PLD test software

1553B-bus support chips

Buscon preview

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



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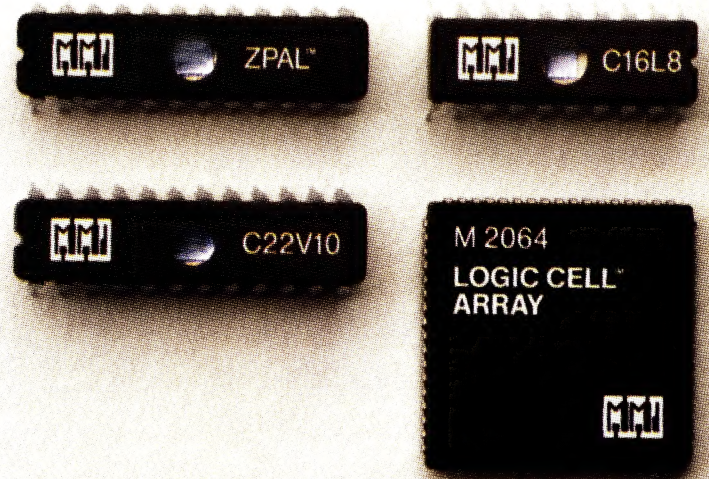

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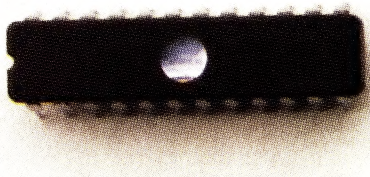

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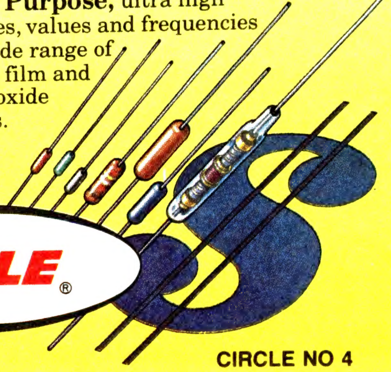

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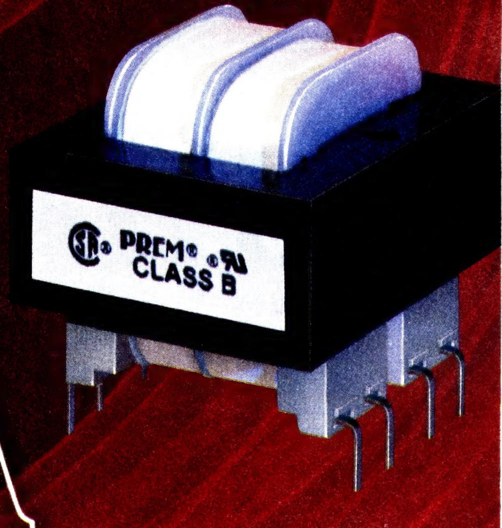

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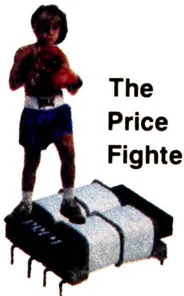

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MODEL	FREQ. RANGE (MHz) f_L to f_u	GAIN dB min	GAIN dB flatness††	MAX. OUT/PWR† dBm	NF dB (typ)	DC PWR 12V, mA	PRICE $ ea. (5-24)
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MAN-2	0.5-1000	19	1.5	7	6.0	85	15.95
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††Midband $10f_L$ to $f_{u/2}$, ± 0.5dB †1dB Gain Compression

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C118 REV. A

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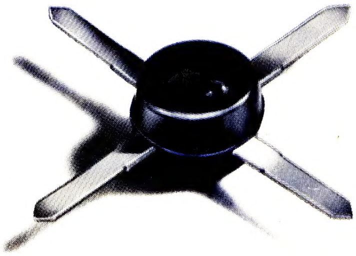

dc to 2000 MHz amplifier series

SPECIFICATIONS

MODEL	FREQ. MHz	GAIN, dB 100 MHz	1000 MHz	2000 MHz	Min. (note)	● MAX. PWR. dBm	NF dB	PRICE Ea.	$ Qty.
MAR-1	DC-1000	18.5	15.5	—	13.0	0	5.0	0.99	(100)
MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8 ☐	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

NOTE: Minimum gain at highest frequency point and over full temperature range.
● 1dB Gain Compression
☐ +4dBm 1 to 2 GHz

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*MAR-8, Input/Output Impedance is not 50ohms, see data sheet. Stable for source/load impedance VSWR less than 3:1

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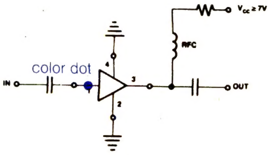
only $59.95



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120 × 60	10%	X7R	.022, .047. .068, .1μf

† Minimum Order 50 per Value

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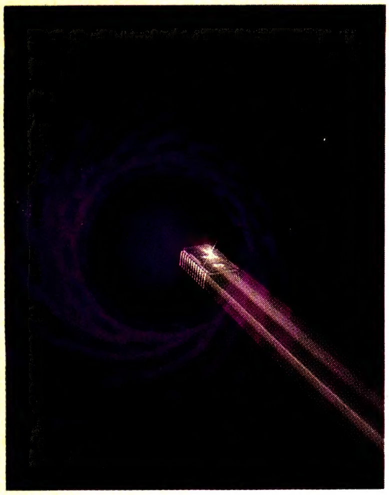
Volume 32, Number 19

September 17, 1987

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *With their 25- to 100-nsec access times, the latest high-speed CMOS EPROMs fit applications such as bit-slice designs, which require speeds you could previously find only in bipolar PROMs. See pg 132. (Photo courtesy Texas Instruments; art direction by Mary Ann Toperzer; illustration by David Neal; photography by Joseph Savant)*

DESIGN FEATURES

Special Report: High-speed EPROMs 132

Today's high-speed EPROMs can deliver access times ranging from 100 to 25 nsec, and the faster of these EPROMs fit into designs that previously required bipolar PROMs.—*Maury Wright, Regional Editor*

EDN's 32-bit-CPU Board Directory 147

Thirty-two-bit microprocessors are bringing mainframe-like power to single-board computers. In EDN's first directory of 32-bit-CPU boards, you'll find boards based on a couple of different μPs. —*John Gallant, Associate Editor*

Partitioning adapts large state machines to PLDs 163

A simple partitioning technique may let you split your state machine into two or more smaller state machines, which may then fit into a single PLD.—*Clive McCarthy, Altera Corp*

Active feedback improves amplifier phase accuracy 179

Using matched op amps and active feedback, you can minimize the phase error and so extend the bandwidth of an amplifier by more than an order of magnitude.—*James Wong, Precision Monolithics Inc*

Isolator measures 12-bit signals across ±3500V barriers 203

By using an isolation amplifier and careful circuit design, you can achieve safe and accurate measurements in the presence of voltages as high as 2500V rms.—*Howard Samuels, Analog Devices*

Terminate bus lines to avoid overshoot and ringing 227

At high frequencies, the traces on a pc board act as transmission lines, so you may need to terminate them to avoid signal distortion caused by impedance mismatches.—*Charles Pace, Fairchild Semiconductor Corp*

Basic program simplifies design of linear power supplies 237

This Basic program prompts you for design specs and then generates the parameters for a workable design.—*George Sayer, Consulting Engineer*

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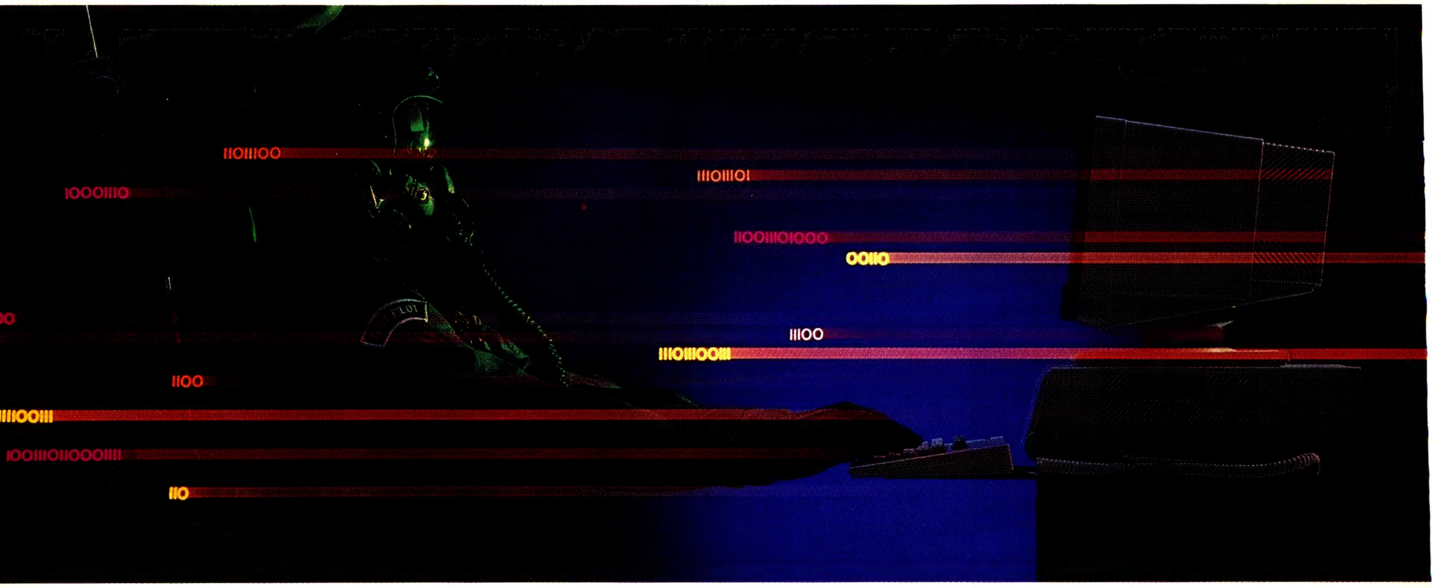

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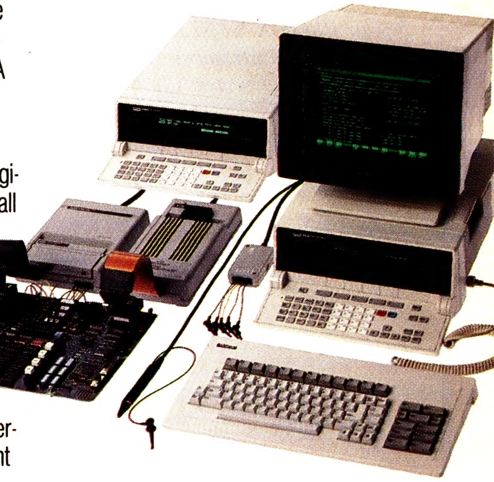

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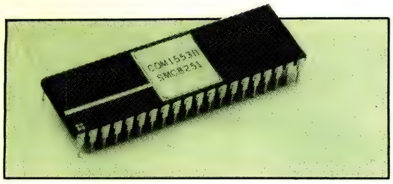
September 17, 1987



The MIL-STD 1553B bus's command-response protocol, *high noise immunity, and dual-redundant bus architecture make the bus as suitable for use in factories and industrial process plants as it is for use in military avionics systems (pg 75).*

TECHNOLOGY UPDATE

Automatic test generators for PLDs clean up your logic designs 59

If you're a design engineer who doesn't develop a comprehensive set of test vectors for your programable logic devices, you're not only passing a tricky problem on to the test department, you're also shortchanging yourself as a designer.—*Charles H Small, Associate Editor*

VLSI support chips let you use the 1553B bus in industrial applications 75

Your industrial networking applications may now be able to reap the benefits of the MIL-STD-1553B bus: Manufacturers have begun to introduce VLSI chips that support communication over the 1553B data bus, yet cost only $100 to $500.—*Peter Harold, European Editor*

Buscon/87: Technical sessions and products for computer-bus designers and users 97

The Buscon/87 show, a combination of product exhibits and technical sessions, moves up the East Coast this year, from New York last fall to Massachusetts this fall.—*EDN Staff*

PRODUCT UPDATE

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Circuit selects single or multiple lines 248
Standard logic provides interrupts for Z80 250
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Current source uses instrumentation amp 254

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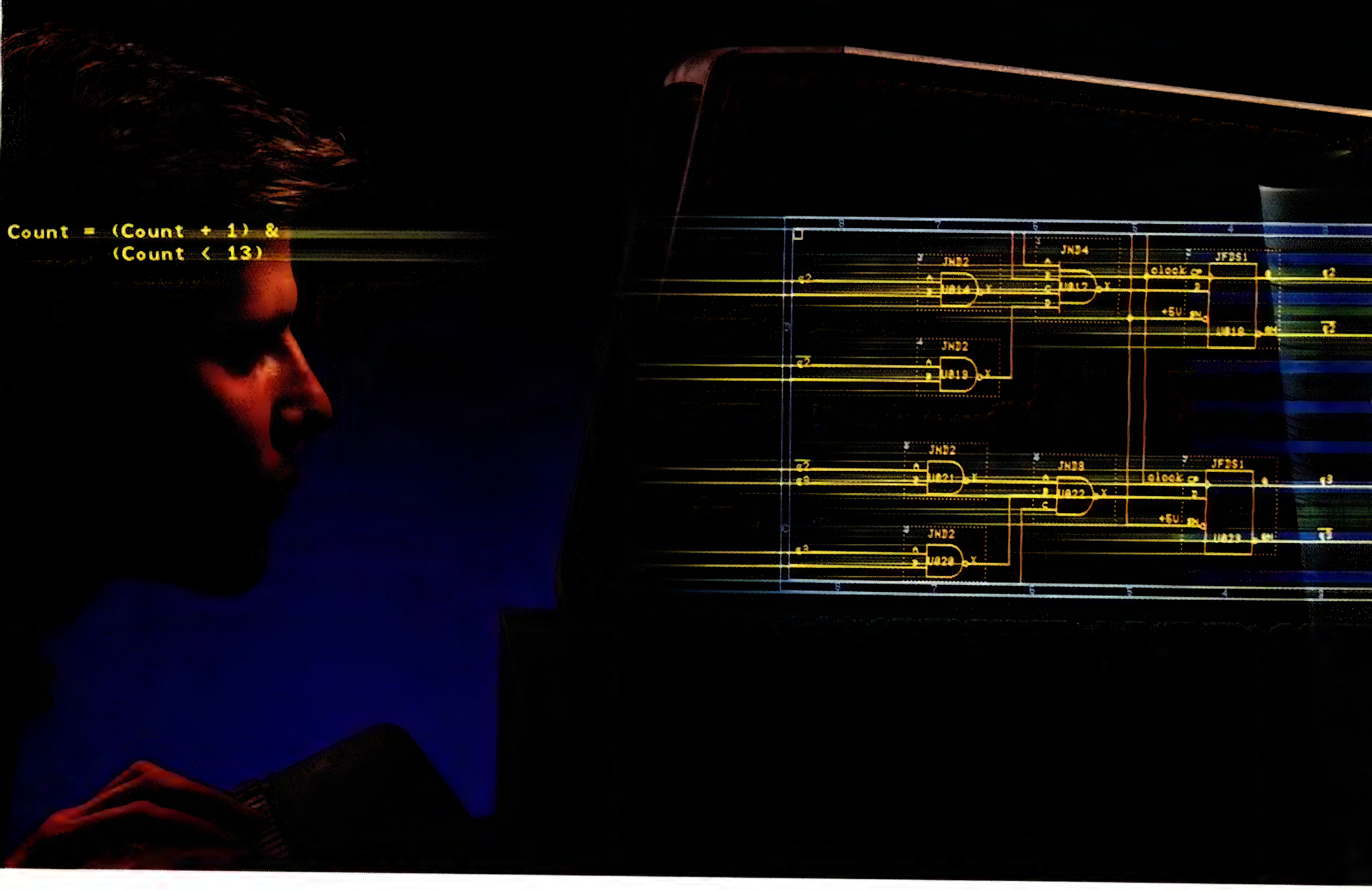

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Engineers at one company share the pride and the profits of successful product design.—*Deborah Asbrand, Associate Editor*

LOOKING AHEAD 349

US modem shipments to double by 1991 . . . Next four years' growth gives SMT-assembly market shape.

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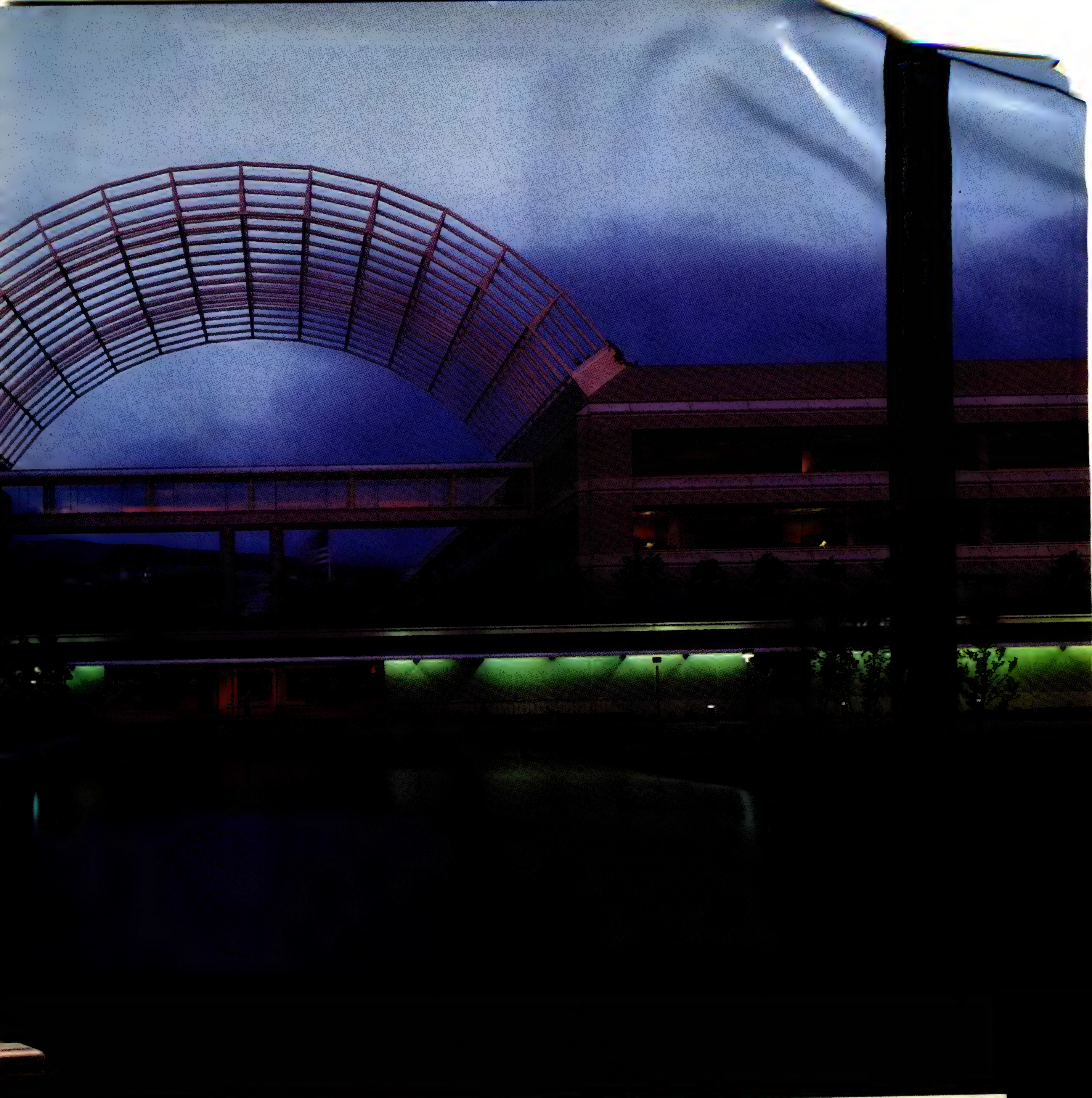

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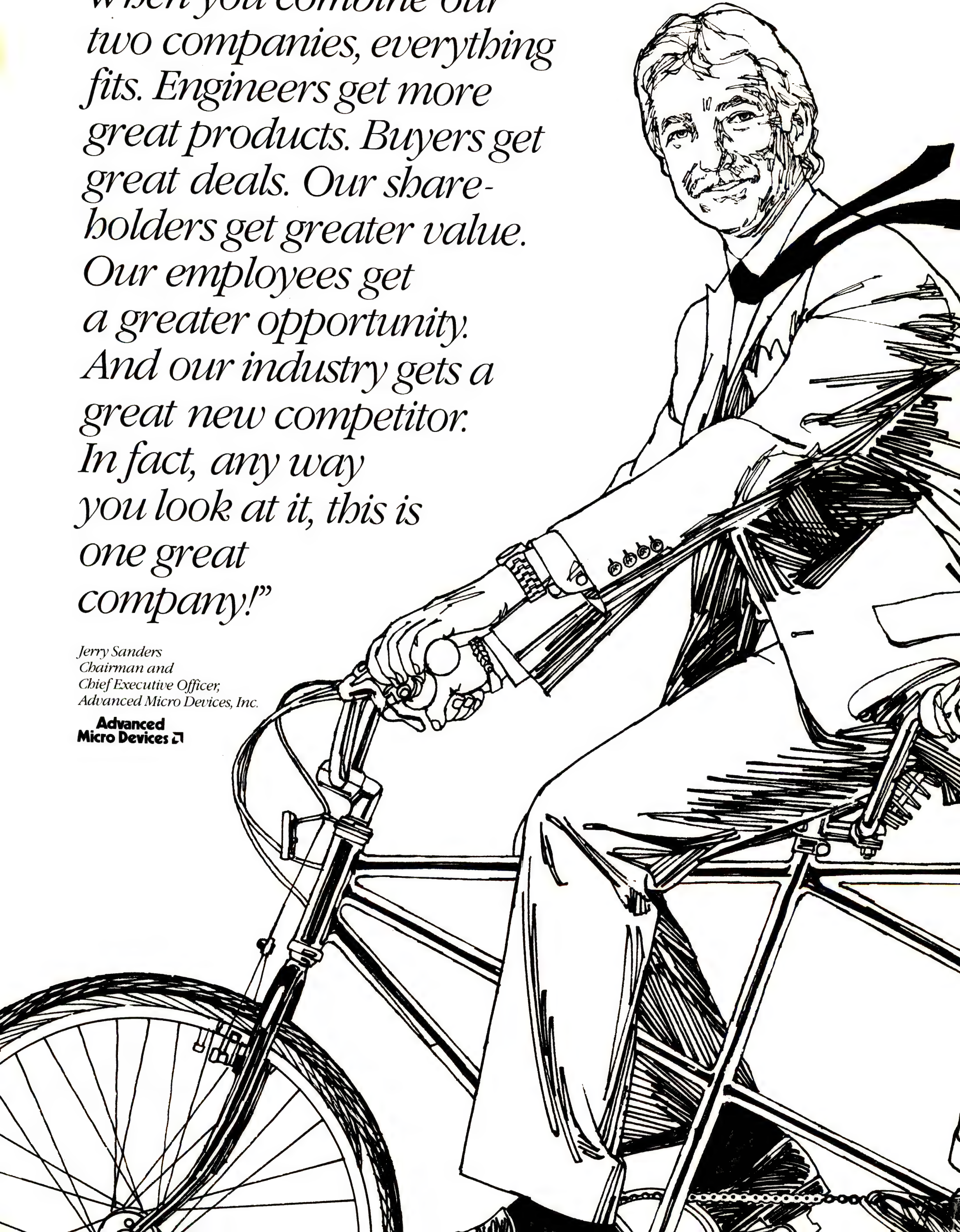

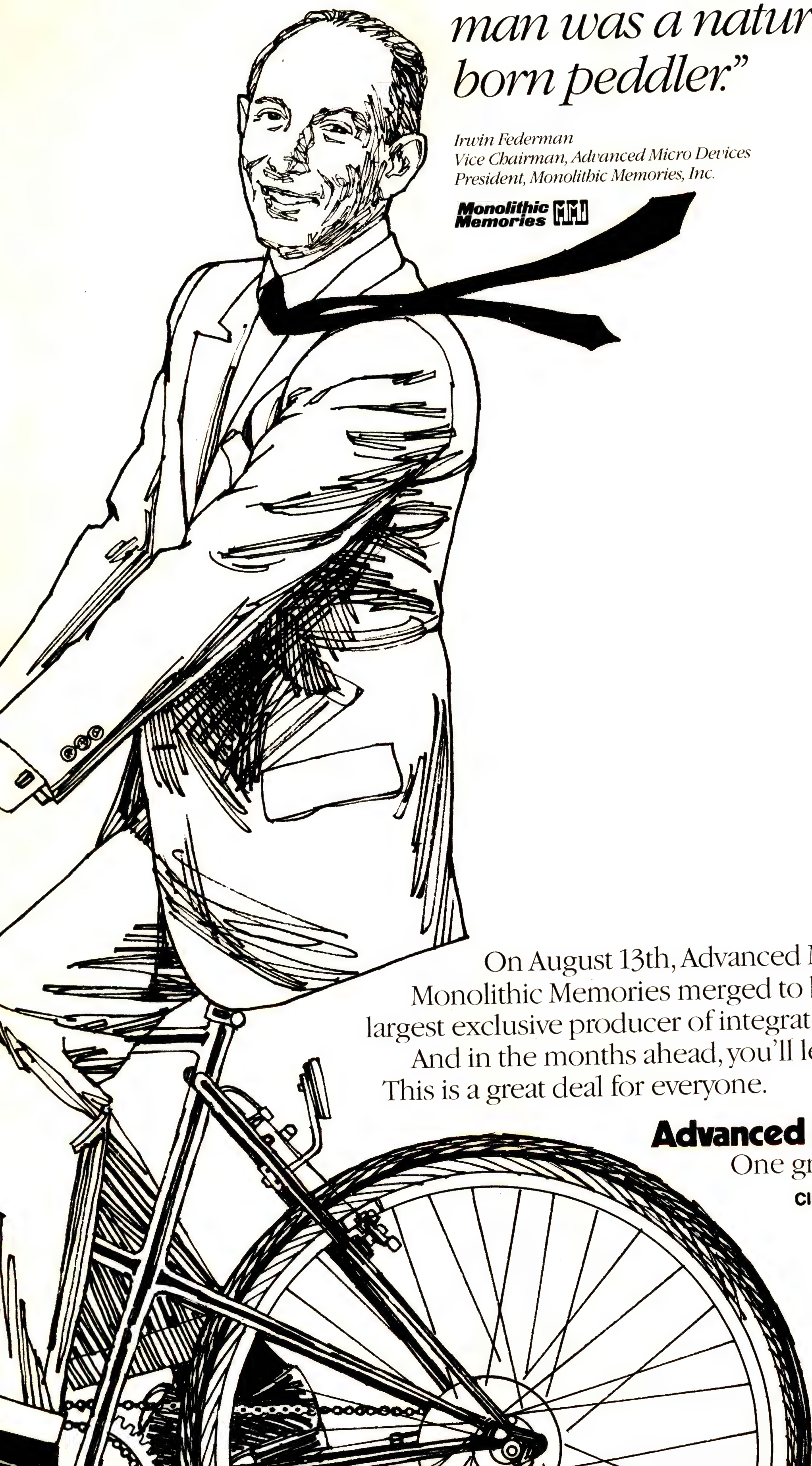

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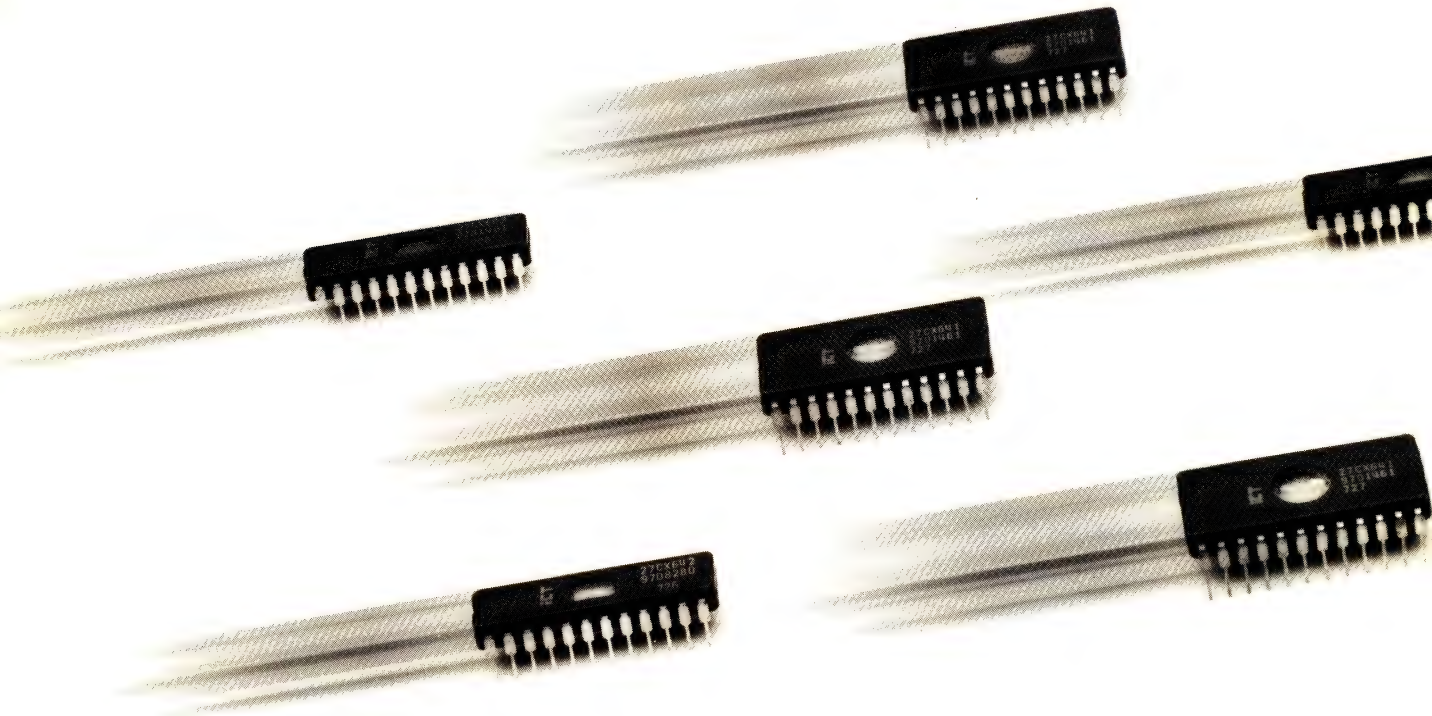

ICT CMOS Erasable PROM Selection Guide

Device	Pins	Pkg.	Organization	Speed	Power
27CX641C-40	24	600 mil	8Kx8	40 ns	80mA max.
27CX641C-45	24	600 mil	8Kx8	45 ns	80mA max.
27CX641C-55	24	600 mil	8Kx8	55 ns	80mA max.
27CX642C-40	24	300 mil	8Kx8	40 ns	80mA max.
27CX642C-45	24	300 mil	8Kx8	45 ns	80mA max.
27CX642C-55	24	300 mil	8Kx8	55 ns	80mA max.

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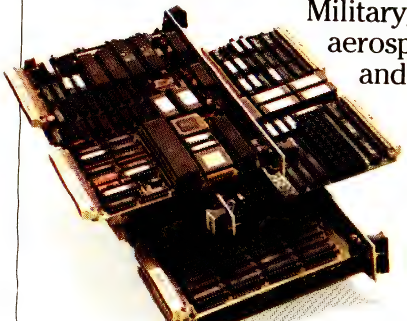

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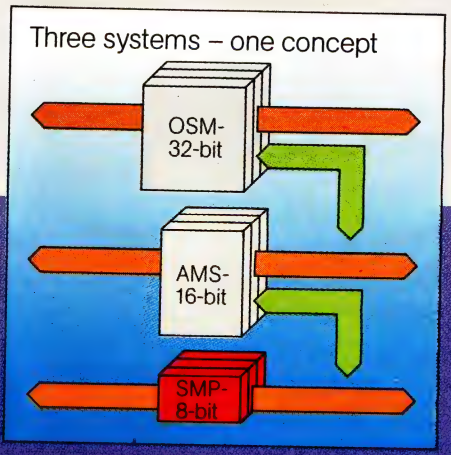

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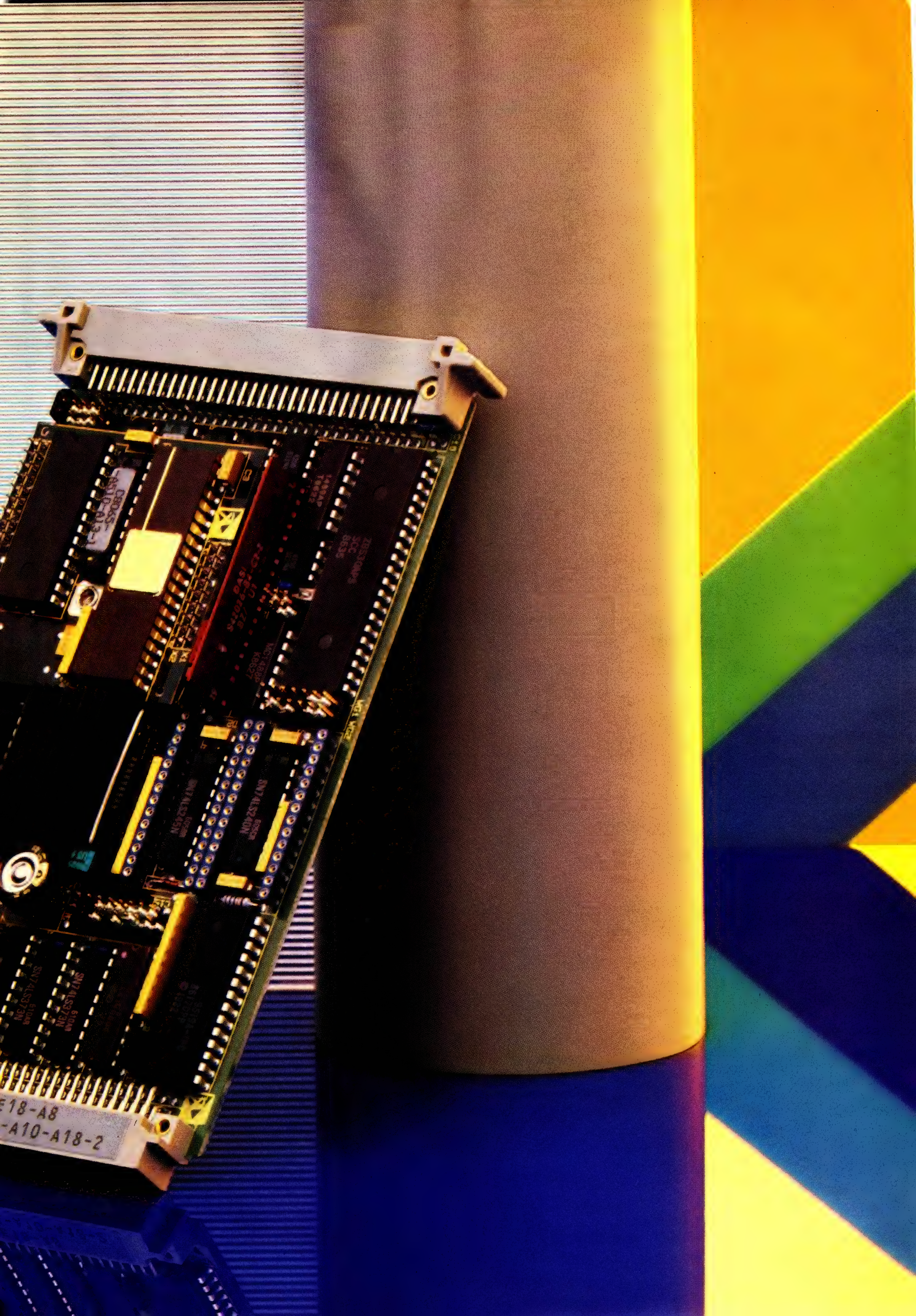
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CIRCLE NO 214

NEWS BREAKS

EDITED BY CLARE MANSFIELD

PC/AT BUS SCSI ADAPTER SENDS 10M-BYTE/SEC BURSTS OF DATA

System integrators can now purchase a high-performance SCSI host adapter, the AHA-1540, to connect disks and other peripherals to personal-computer-class machines. Adaptec's (Milpitas, CA, (408) 432-8600) PC/AT bus-compatible host adapter sends bursts of data across the host bus at speeds as high as 10M bytes/sec. Furthermore, it performs 2M-byte/sec asynchronous and 5M-byte/sec synchronous transfers to SCSI Bus peripherals. The host adapter suits a multitasking I/O environment and targets new PC/AT-class machines that will host Unix, Xenix, and other multiuser, multitasking environments. In MS-DOS applications, the adapter emulates a standard PC/AT bus disk controller. Samples of the board are available now, and production quantities will be available in the fourth quarter for $285 (100).—Maury Wright

HIGH-RESOLUTION TOUCHSCREEN USES SAW TECHNOLOGY

Elographics (Oak Ridge, TN, (615) 482-4100), a major supplier of resistive-membrane touchscreens, has developed a touchscreen based on SAW technology. The company claims SAW-based screens are more rugged and offer a higher resolution than older touchscreen technologies such as resistive membrane and LED. Surface-mounted piezoelectric transducers at the edge of the screen propagate mechanical waves within the screen's glass surface. Any soft object pressing on the screen, such as a finger, attenuates the wave. The scanning arrays can determine the x and y coordinates of the pressure point to a resolution of 1/100 in. The degree of attenuation of the wave indicates the amount of pressure applied, providing a z coordinate. A 13-in. diagonal screen with electronics costs $340 (1000); allow 45 days for prototype delivery.
—Margery S Conner

PORTABLE INSTRUMENT TESTS T1 AND DDS SYSTEMS

The HP 3787B digital-data test set from Hewlett-Packard Co (Palo Alto, CA) provides bit-error-rate (BER) measurements on in-service and out-of-service T1, digital-data-service (DDS), and 56k-bps switches and packet-switched services. By testing in-service equipment, you can detect line degradation before service is seriously affected, catch problems that occur only at certain times or under particular loading conditions, and identify problems that need attention prior to taking a line out of service for maintenance. The $8000 instrument also provides an RS-232C port, allowing connection to an asynchronous protocol analyzer for digital-storage-oscilloscope subrate testing.—Steven H Leibson

AMERICAN-MADE AC/DC ADAPTERS COMPETE WITH OFF-SHORE PARTS

If you're in the market for external ac/dc power supplies, James Electronics (Chicago, IL, (312) 463-4500) manufactures a line of 16 and 4W plug-in adapters with outputs ranging from 6 to 28V. Boasting prices of $1.80 to $2.50 (OEM qty), the Competitor Series meets UL, FCC, and CSA requirements. Their cases, constructed of high-impact plastic, measure 2.35×2.15×1.67 in.^{3} You can order customized markings, cables, and plug configurations to suit your application.—J D Mosley

NEWS BREAKS

16 EPROMs CAN BE PROGRAMMED AND TESTED IN UNDER 10 SEC

The Turbosocket PROM-programming adapter from Oliver Advanced Engineering (Glendale, CA, (818) 240-0080) contains a high-speed DMA channel for each of its eight or 16 sockets, allowing it to read, write, blank-test, and verify EPROMs at 250k to 1M bytes per second per socket. The machine can program and test 16 27C256 EPROMs, for example, in less than 10 seconds. The software-configured pin drivers also support parametric screening for ESD damage and excessive leakage currents and power consumption. The adapter plugs into the manufacturer's OMNI 64 programmer. Prices for the adapter alone start at $1995; prices for the complete system start at $9350.

—Margery S Conner

TRANSLATOR CONVERTS TMS320 DSP CODE TO MOTOROLA 56000

You can now order a code translator from Motorola (Austin, TX, (512) 928-6000) to ease the switch from Texas Instruments' TMS320 DSP devices to Motorola's 56000 DSP family. For $50 you get a disk with programs that translate 32010 files to 56000 ones. The software uses two methods of 32010 emulation: It either generates in-line 56000 code, or it uses subroutine calls for each 32010 instruction. Although the in-line code generator produces faster code, it can't recompile 32010 code if the code changes during the program's execution (called self-modifying code). The subroutine method, which transfers 32010 op codes to a 56000-loadable file, produces slower code, but solves the self-modified-code problem. Other software provides a C language source file for your converted code.—J D Mosley

NEW LOGIC TRIPLES THE PERFORMANCE OF 10K AND 100K ECL

Motorola's (Phoenix, AZ, (602) 962-2190) new family of high-speed logic, called Eclipse for "ECL in picoseconds," offers triple the performance of earlier 10K and 100K ECL families. The parts include flip-flops that toggle at 600 MHz min and gates with propagation delays of 350 psec typ, 500 psec max. All offerings come in 28-lead PLCCs (plastic leaded chip carriers).

Sample products are becoming available now, and 14 parts (eg, clock drivers, registers, and multiplexers) will be phased into production by mid-1988. To ease the interfacing of ECL gate arrays to the major ECL standards, each Eclipse device will come in a 10K- and a 100K-compatible version. Average prices are expected to be $12 (100).

—Tarlton Fleming

VECTOR PROCESSORS CONVERT VERSACAD FILES

Two new vector-to-raster converters from KMW Systems Corp (Austin, TX, (512) 338-3000) let you translate VersaCAD output files from vector data to raster format so that you can use them with electrostatic, thermal, and laser plotters. The $5995 VP-10 accepts VersaCAD's Hewlett-Packard Graphics Language (HPGL) output files and converts them for use with low-cost devices such as A- or B-size color thermal printers and lasers. You can also use it to make electrostatic prints that are no more than 24 in. wide. The VP-30 works with files that are as wide as 44 in. It costs $21,500.

—J D Mosley

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CIRCLE NO 215

NEWS BREAKS: INTERNATIONAL

SUPERMINIS ACHIEVE A PER-ACTIVE-USER COST OF LESS THAN £5000

By making extensive use of CMOS gate arrays, Norsk Data (Oslo, Norway, TLX 78284) has reduced the size of the CPU for its 32-bit superminicomputers from 21 separate plug-in boards to a single 3-board sandwich plug-in assembly. As a result, the new ND-5000 Compact range of minicomputers fits in cabinets 69 cm high, consumes 1.1 kW max, and starts at £36,000, yet offers a processing power of 0.5 to 6.5 Whetstones. You can upgrade from one model to another across the entire range. The minicomputers provide connectivity for as many as 115 terminals and are available with either internal or external hard disks. They support Unix and the OSI model and X.25 standards.—Peter Harold

ADD-IN CARD BOOSTS IBM PC/AT's PERFORMANCE TO 90 MIPS

Equipped with nine T414 or T800 transputers, each with 1M bytes of RAM, the Fast9 add-in board from Quintek Ltd (Bristol, UK, TLX 449683) provides IBM PC/AT computers with 90 MIPS or 13.5M flops of processing power. Eight of the transputers are connected as a chain via transputer links. In addition, two transputer links from each transputer are routed via a software-programmable crossbar switch to other onboard transputers or to an expansion connector, allowing you to modify the topology of the transputer array and to cascade boards. The ninth transputer controls the crossbar switching and supervises operation of the other eight transputers. The board costs $25,950.—Peter Harold

ECL GATE ARRAYS TRADE POWER DISSIPATION FOR SPEED

Beginning in the second quarter of 1988, Siemens (Munich, West Germany, TLX 5210025) will accept designs for its 2500-gate SH100E ECL gate arrays. During 1988, the company plans to expand the gate-array family to include arrays with gate counts from 1000 to 10,000. The currently available cell library of ECL and CML (current-mode-logic) logic functions allows you to make speed/power tradeoffs by selecting one of three power levels for each cell. If your design requires that part of the logic run faster than other parts, you can mix the three power levels on a single device, provided that you stay within the maximum power dissipation of the device's pin-grid-array package. For the 2500-gate array, the company predicts nonrecurring layout and prototyping charges of less than DM 100,000, and a unit price of less than DM 500 (1000).—Peter Harold

LCD DISPLAYS WHITE CHARACTERS ON A BLACK BACKGROUND

Sharp Electronics (Mahwah, NJ, (201) 529-8757), the US sales and marketing arm for Sharp Corp, is offering a white-mode, double-super-twist LCD, the LM72060Z. The display shows black characters against a white background and has an effective display area of 260×147 mm. The contrast ratio is 1:15, the dot pitch is 0.3750×0.35 mm, and the dot-pitch ratio is 1:1. The LCD will be available in sample quantities beginning in October; in production quantities, it will cost approximately $300.

—Clare Mansfield

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Min. Pass Band (MHz) DC to		10.7	22	32	48	60	98	140	190	270	400	520	580	700	780	900
Max, 20dB Stop Frequency (MHz)		19	32	47	70	90	147	210	290	410	580	750	840	1000	1100	1340

Prices (ea.): P $9.95 (6-49), B $24.95 (1-49), N $27.95 (1-49), S $26.95 (1-49)

HIGH PASS **Model**	***HP-**	**50**	**100**	**150**	**200**	**250**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
Pass Band (MHz)	start, max.	41	90	133	185	225	290	395	500	600	700	780	910	1000
	end, min.	200	400	600	800	1200	1200	1600	1600	1600	1800	2000	2100	2200
Min. 20dB Stop Frequency (MHz)		26	55	95	116	150	190	290	365	460	520	570	660	720

Prices (ea.): P $12.95 (6-49), B $27.95 (1-49), N $30.95 (1-49), S $29.95 (1-49)

*Prefix P for pins, B for BNC, N for Type N, S for SMA   *example:* **PLP-10.7**

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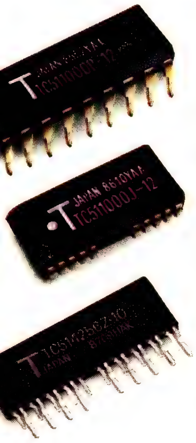

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TOSHIBA 1 Mb DRAMs					
rt Number	Organization	Process	Speed	Mode	Package
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C511000 - 10	1 Mb x 1	CMOS	100 ns	Fast Page	18 pin
C511000 - 12	1 Mb x 1	CMOS	120 ns	Fast Page	18 pin
C511001 - 85	1 Mb x 1	CMOS	85 ns	Nibble	18 pin
C511001 - 10	1 Mb x 1	CMOS	100 ns	Nibble	18 pin
C511001 - 12	1 Mb x 1	CMOS	120 ns	Nibble	18 pin
C511002 - 85	1 Mb x 1	CMOS	85 ns	Static Column	18 pin
C511002 - 10	1 Mb x 1	CMOS	100 ns	Static Column	18 pin
C511002 - 12	1 Mb x 1	CMOS	120 ns	Static Column	18 pin
C514256 - 85	256K x 4	CMOS	85 ns	Fast Page	20 pin
C514256 - 10	256K x 4	CMOS	100 ns	Fast Page	20 pin
C514256 - 12	256K x 4	CMOS	120 ns	Fast Page	20 pin
C514258 - 85	256K x 4	CMOS	85 ns	Static Column	20 pin
C514258 - 10	256K x 4	CMOS	100 ns	Static Column	20 pin
C514258 - 12	256K x 4	CMOS	120 ns	Static Column	20 pin

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Part Number	Organization	Process	Speed	Standby Power	Package
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TC55257L-10	32K x 8	CMOS	100 ns	100µA MAX	28 pin
TC55257AL-12	32K x 8	CMOS	120 ns	100µA MAX	28 pin
TC55257AL-85L	32K x 8	CMOS	85 ns	30µA MAX	28 pin
TC55257AL-10L	32K x 8	CMOS	100 ns	30µA MAX	28 pin
TC55257AL-12L	32K x 8	CMOS	120 ns	30µA MAX	28 pin

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CIRCLE NO 219

Some notes on codecs

With regard to my two articles on codecs ("Consider standard features when selecting codecs," EDN, April 30, pg 211 and "Check advanced features and noise specs when selecting codecs," EDN, May 14, pg 227), I'd like to add the following information.

"Combo" (actually "COMBO I" and "COMBO II") is a registered trademark of National Semiconductor. That company has just introduced a series of codecs, the TP3070 and TP3071, that I would have included in my discussion of advanced codec features if I'd had access to their preliminary data sheets at the time I wrote the article.

Further, in reply to G W Foreman's letter (EDN, August 6, pg 31) regarding some errors in the section entitled "Understanding noise specifications" (pgs 229 to 234 of the second article), I stand corrected. I appreciate the additional information and history his letter provided, and I apologize for the errors and any confusion they may have caused.

Brady Barnes
Inter-Tel
Chandler, AZ

"FIRST THE GOOD NEWS: YOU'RE BEING TRANSFERRED TO REYKJAVIK, ICELAND!"

Single-port chip set runs at full speed

I read with interest Steve Leibson's Special Report entitled "Microprogrammable processing" in EDN's April 15 issue (pg 142). I was sorry to see that **Table A** (pg 149) did not include the recently introduced ADSP-3211/3221 floating-point chip set.

In addition, the text above the table suggests that 2-port devices (as the ADSP-3210 is listed in the table) suffer from I/O bottleneck problems. In fact, the ADSP-3210's single port is adequate to keep the chip running at full speed, because it transfers data twice per cycle.

David Fair
Strategic Marketing Manager
Analog Devices
Norwood, MA

Text continued on pg 34

PERFECT TIMING!

Rhombus has created some brand new TTL delay modules — just when you needed solutions to your circuit-timing problems.

Now, Rhombus high quality TTL delay modules are also available in auto-insertable, 8 pin auto-insertable mini-dip, and surface mount packages. Designed to speed installation and save space, these new delay modules meet the same high-performance levels of all Rhombus delay lines, and meet or exceed all applicable environmental requirements of MIL-D-23859, MIL-STD-883 and MIL-STD-202.

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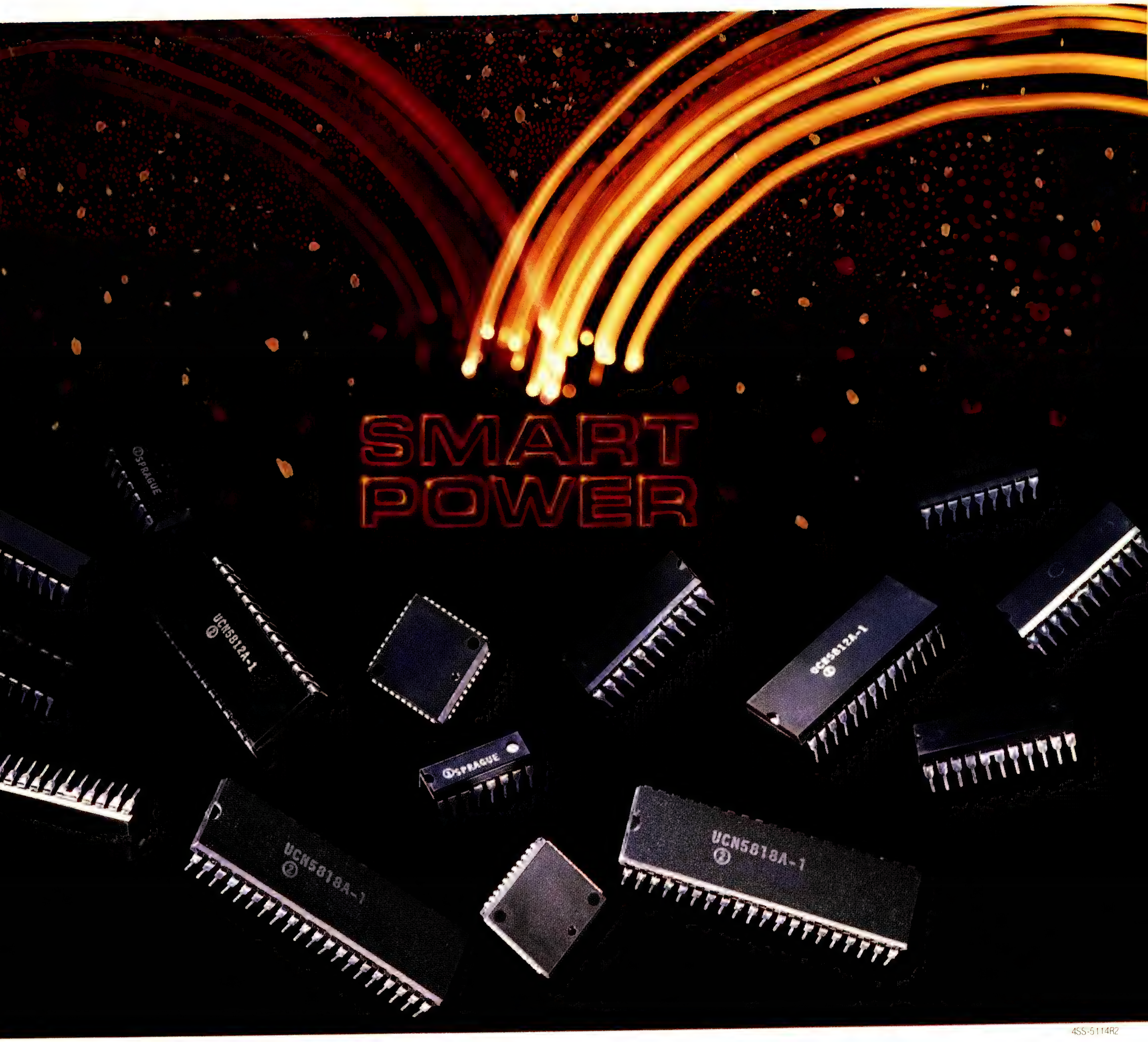
CIRCLE NO 1

BLENDING TECHNOLOGIES.



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SIGNALS & NOISE

Readers' comments

- *Engineering layoffs*

"The article on layoffs in Professional Issues [EDN, January 22, pg 303] was right on. Having gone through it a year and a half ago, I still feel the effects. The article should have stressed how engineers' attitudes have changed because of the experience."—*T M, Richardson, TX*

"The article on layoffs is one I can relate to. The worst part is seeing the writing on the wall and trying to tell management; they refuse to hear you. Then when the time comes for layoffs, workers are laid off and managers are kept."—*M G, Denton, TX*

- *Unpaid overtime*

"The article on unpaid overtime [EDN, April 30, pg 285] strikes dead center. When you consider that 9-month design cycles, cutthroat competition, and miraculous innovation define the winner in today's market, you begin to realize how underpaid engineers are."
—*J H, Longmont, CO*

"After over 25 years in engineering, when I look back, I find my best advancements professionally and in salary were when I refused uncompensated overtime. I don't believe uncompensated overtime is beneficial to either the employee or the company."—*R P, Upland, CA*

"Project-driven engineering is as much a characteristic of government products as of commercial ones. The 'scheduled overtime' allowed in government contracts is not what it implies, because what is most frequently encountered is unscheduled overtime that's used to meet deadlines or crisis situations."—*L J, Columbia, MD*

"The article entitled 'Widespread practice of unpaid overtime levies burden on salaried engineers' was very commendable. It specified problem areas and revealed the ultimate contradiction in our 'American work ethic.' "—*M G, Seattle, WA*

WRITE IN

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CIRCLE NO 2

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These high-performance digitizing oscilloscopes let you measure what you've never measured before, with superb accuracy and ease of use.

You'll find innovations such as 20 GHz bandwidth, 4-channel simultaneous 400 MSa/sec with 64k memory per channel, time domain reflectometry (TDR) with normalization, 10 psec time interval accuracy, and more.

HP 54111D: the hot single shot.

The HP 54111D offers two simultaneous channels operating at up to 1 Gigasample per second...allowing you to capture high-speed single-shot phenomena such as high-speed pulses, plasma discharge, high voltage arcing, high frequency bursts, laser pulses and high energy events.

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- ☐ 500 MHz repetitive bandwidth
- ☐ 250 MHz single-shot bandwidth
- ☐ 8k memory per channel
- ☐ 1 mV/div sensitivity

HP 54112D

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- ☐ 100 MHz repetitive or single-shot
- ☐ 4 simultaneous channels
- ☐ 64k memory per channel

rmance digitizing oscilloscopes.

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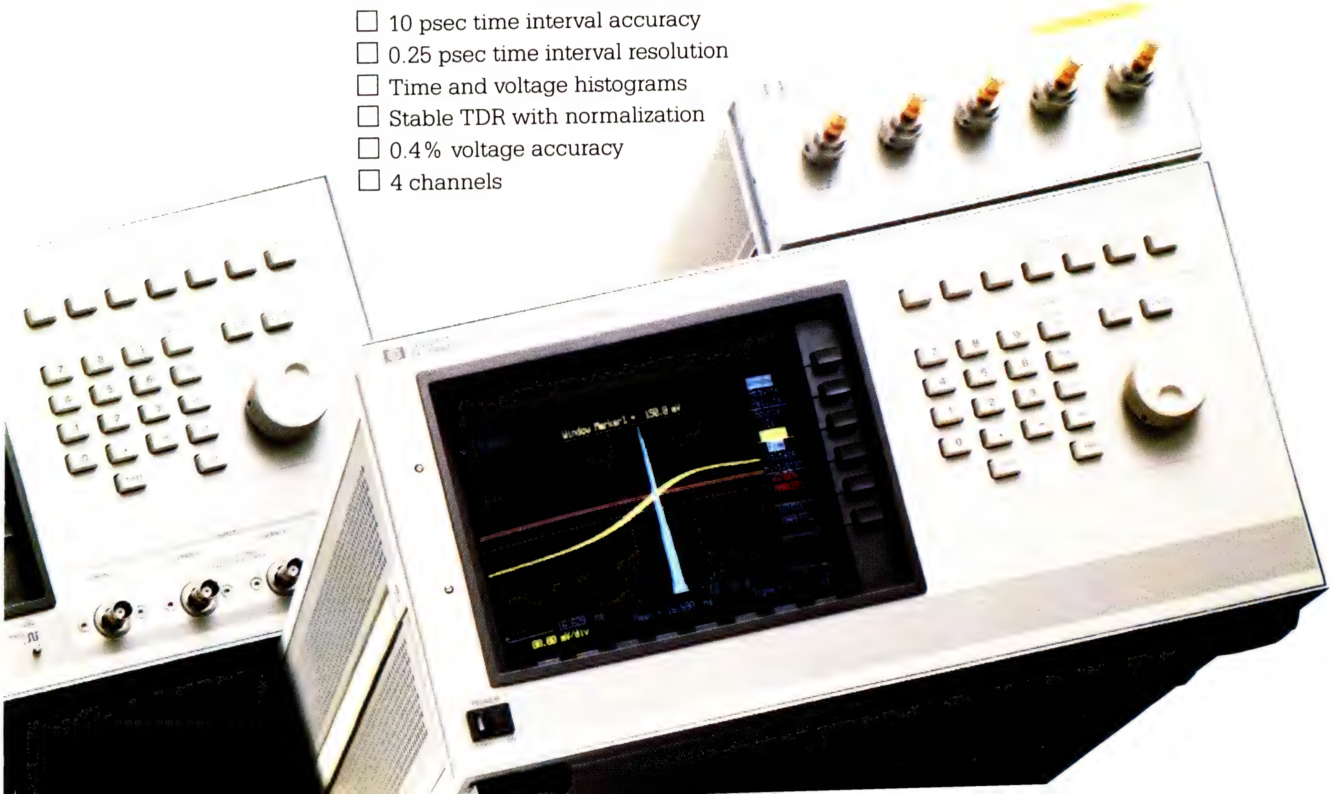
☐ 4 channels



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Sensitivity	1 mV/div to 5 V/div
Coupling	ac, dc; 50 Ohm & 1 MOhm
HORIZONTAL:	
Digitizing rate (max)	1 GSa/sec
Resolution	10 psec
Pre-trigger viewing	YES
MEMORY:	
Acquisition/chan	8k
Waveform storage	2 pixel, 4 rep wfm, 4 ss wfm
Nonvolatile instrument setups	10

HP 54112D $22,900.00*

VERTICAL:	
Rep. bandwidth	100 MHz
S.S. bandwidth	100 MHz
Inputs	4 chan & 1 trig
Resolution	6 bit to 100 MHz
Sensitivity	5 mV/div to 5 V/div
Coupling	ac, dc; 50 Ohm & 1 MOhm
HORIZONTAL:	
Digitizing rate (max)	400 MSa/sec
Resolution	40 psec
Pre-trigger viewing	YES
MEMORY:	
Acquisition/chan	64k
Waveform storage	2 pixel, 4 rep wfm, 4 ss wfm
Nonvolatile instrument setups:	10

HP 54120T $27,850.00**

VERTICAL:	
Rep. bandwidth	20 GHz
S.S. bandwidth	NO
Risetime	17.5 psec
Accuracy	0.4%
Inputs	4 chan & 1 trig
Resolution	12 bits
Sensitivity	1 mV/div to 80 mV/div
Coupling	50 Ohm
HORIZONTAL:	
Accuracy	10 psec
Resolution	0.25 psec
Pre-trigger viewing	NO
Range	10 psec/div-1 s/div
MEMORY:	
Acquisition/chan	0.5k
Waveform storage	2 pixel (volatile), 4 rep wfm (nonvolatile)
Nonvolatile instrument setups:	10
TDR	
Pulse source	
Amplitude	0-200 mV
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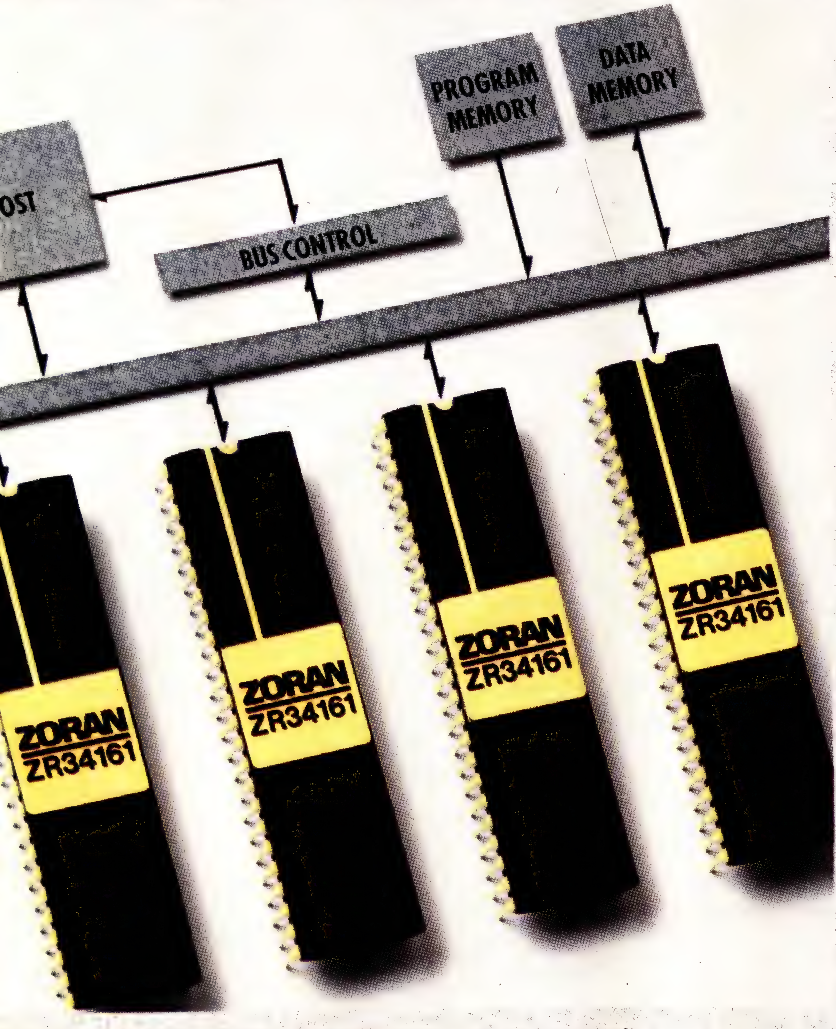

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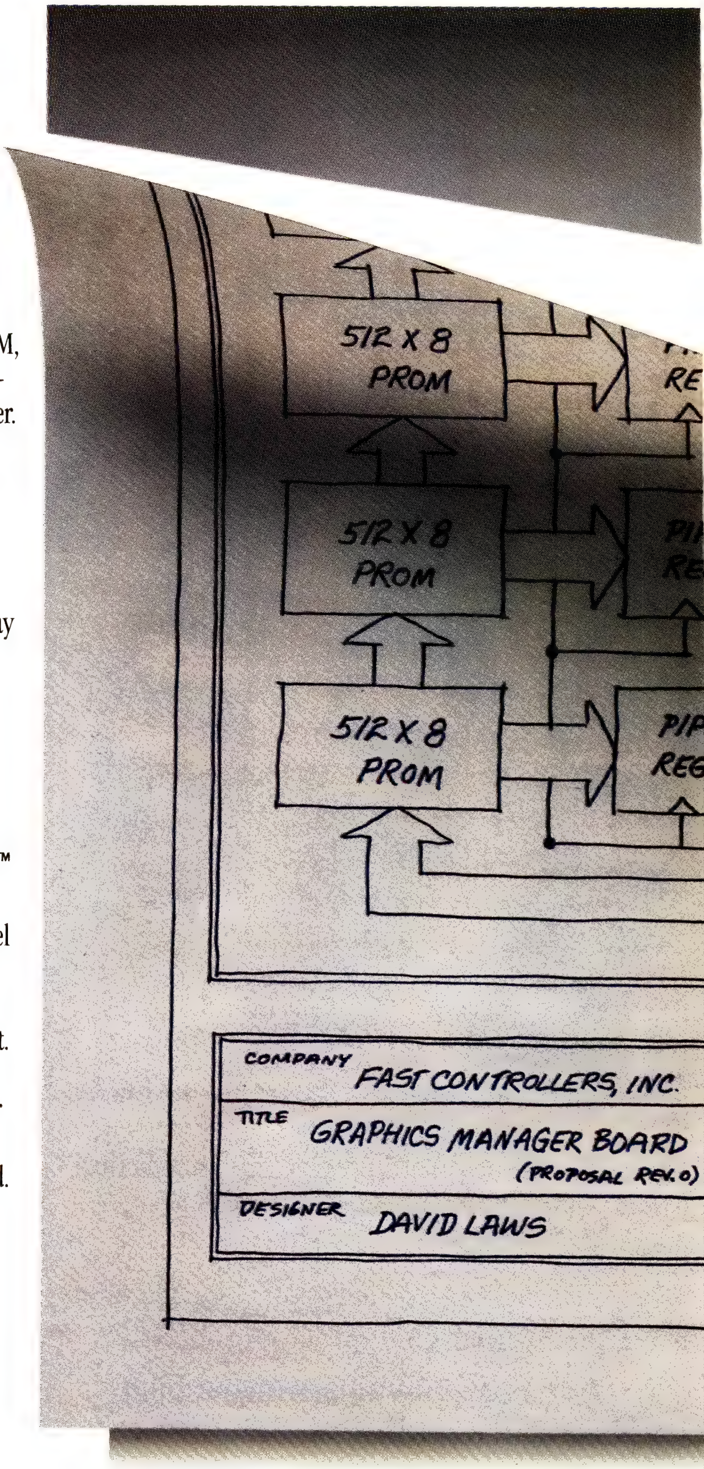

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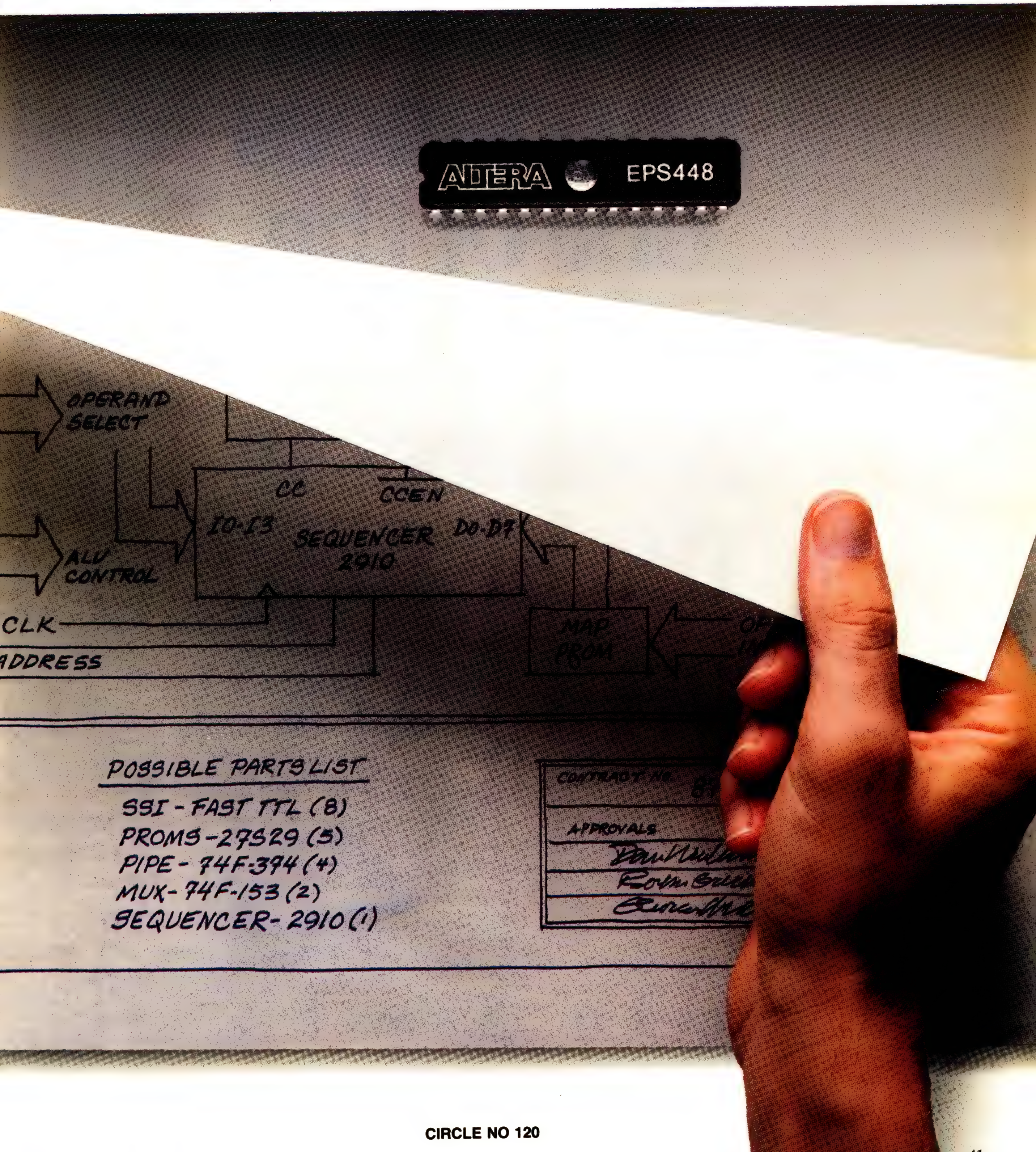
State of Mind.

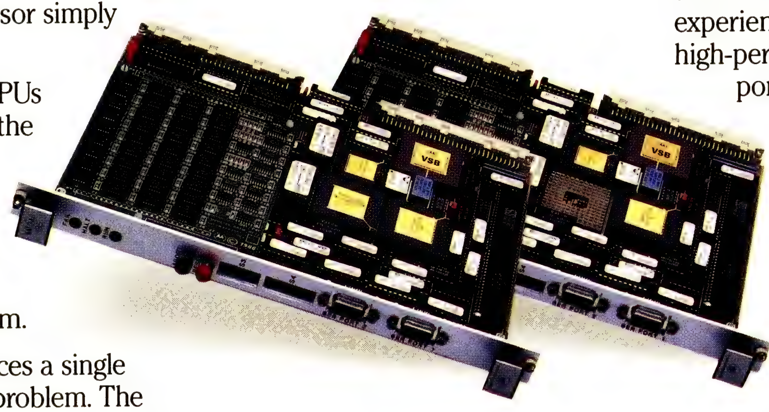


CIRCLE NO 120

Motorola announces one of the smallest advances in the history of VME.

Motorola puts awesome multiprocessing performance on two new single-board computers.

As computer applications get more complex, OEMs are turning more to multiprocessing designs. To handle things like CAD/CAM, robotics, signal processing, simulation and large-scale data acquisition, a single processor simply can't keep up.



Adding several CPUs to a system off-loads the main processor, but what happens to the system bus? It frequently reaches saturation, slowing down the entire system.

Motorola introduces a single chip solution to this problem. The **V**ME **S**ubsystem **B**us, a fast, 32-bit secondary bus, has been implemented on a gate array at Motorola.

The end of the multiprocessor traffic jams.

The VSB sub-bus removes traffic from the VMEbus, increasing total system throughput. And by saving space on the VSB–and other components–Motorola has been able to pack an impressive array of multiprocessor functions onto two standard VME boards: the MVME135 and MVME136. These highly integrated microcomputers include *all* the functions usually required for high-performance multiprocessing. In addition to the VSB, they feature the MC68020 with floating-point coprocessor, both running at either 16.67 or 20.0MHz.

For virtual memory environments, a demand-paged memory management unit can also be added. Plus 1 Megabyte of shared local dynamic RAM is included–with optional parity–designed to operate with zero wait states.

Included in the 135/136 modules are many special hardware features that facilitate multiprocessing. Things like MP control and status registers. An expanded interrupt-handling mechanism. And master/slave control bit settings.

Hardware alone is hardly enough.

Complete multiprocessing hardware on a single board saves you design time and system space. But to get your application up and running on a tight schedule, it takes software and support tools too. Like those available from Motorola.

If you're building a multi-user/multi-tasking system, you can use our version of AT&T's UNIX® System V Release 3, with Remote File Sharing. For real-time tasks, there's our full-featured VERSAdos™ operating system, as well as debugging firmware with on-board diagnostics. Then too, you have access to third-party software such as OS-9,™ MTOS,™ PDOS,™ pSOS,™ RTUX,™ and VRTX.®

Add to that Motorola's in-depth technical support. We have more experience in building reliable, high-performance VME system components than any other vendor. Plus a specialized systems and support staff available at over 100 field offices worldwide.

To see how good multiprocessors can come in small packages, call us toll-free today: **1-800-556-1234 Ext. 230** (in California, 1-800-441-2345 Ext. 230). Or write; Motorola Microcomputer Division, 2900 South Diablo Way, Tempe, AZ 85282.

MVME135/136 Highlights

Model	Description
MVME135	VMEbus 32-bit SBC; 16.67-MHz MC68020 CPU; MC68881 FPU; 1Mb on-board DRAM; up to 512 Kb EPROM; two RS-232-C serial ports; two 16-bit timers; master/slave interface; MP control and status registers; system controller
MVME135-1	Same as MVME135, but with 20-MHz MC68020 CPU
MVME136	Same as MVME135, but with MC68851 PMMU

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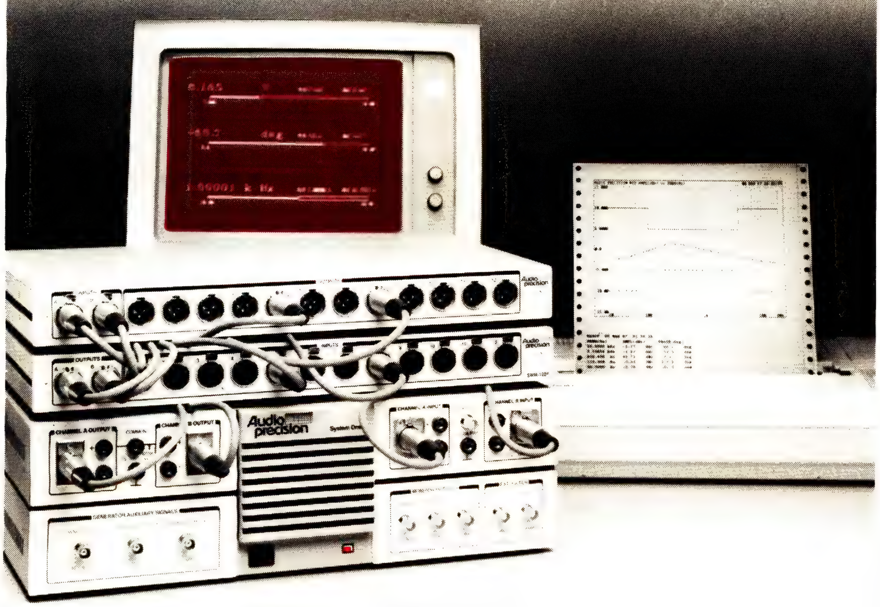


CIRCLE NO 3

CALENDAR

2nd International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS-II), Palo Alto, CA. Martin Freeman, Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94086. (408) 991-3591. October 5 to 8.

IEEE International Conference on Computer Design: VLSI in Computers and Processors, Port Chester, NY. Michael Wayne, IBM, Dept B34, Bldg 901-3, Box 390, Poughkeepsie, NY 12603. (914) 432-5211. October 5 to 8.

Invitational Computer Conference Computer Graphics Series, Irvine, CA. BJ Johnson & Associates, 3151 Airway Ave, #C-2, Costa Mesa, CA 92626. (714) 957-0171. October 13.

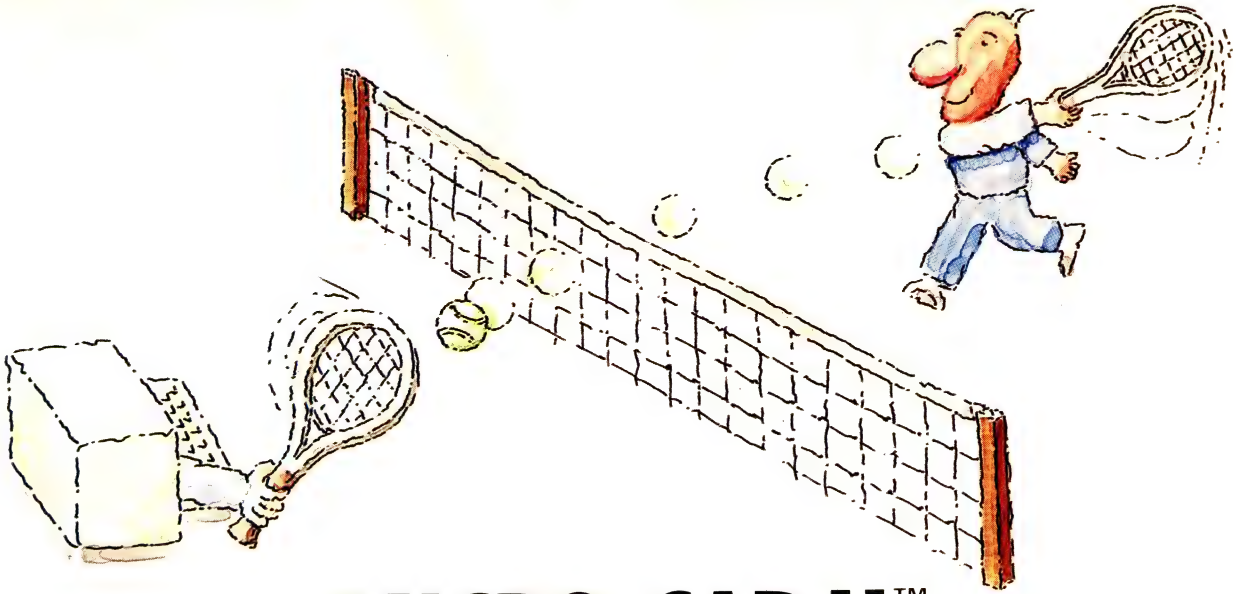
IEEE Fifth Biennial Careers Conference, San Diego, CA. IEEE, 1111 19th St NW, Suite 608, Washington, DC 20036. (202) 785-0017. October 14 to 16.

6th Annual Pacific Northwest Computer Graphics Conference, Eugene, OR. University of Oregon Continuation Center, 1553 Moss St, Eugene, OR 97403. (503) 686-3537. October 25 to 27.

Expo SMT, Las Vegas, NV. Expo SMT, Box 1869, Los Gatos, CA 95031. (408) 354-0700. October 26 to 29.

International Fiber Optic Communications and Local Area Networks Exposition, Anaheim, CA. Information Gatekeepers, 214 Harvard Ave, Boston, MA 02134. (617) 232-3111. October 26 to 30.

Government Microcircuits Applications Conference (GOMAC '87), Orlando, FL. Palisades Institute for Research Services, 201 Varick St, New York, NY 10014. (212) 620-3371. October 27 to 29.



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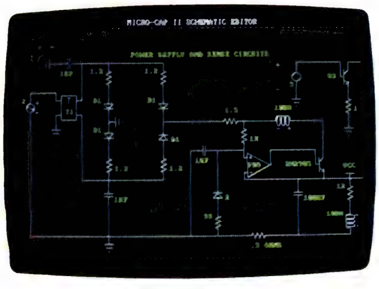
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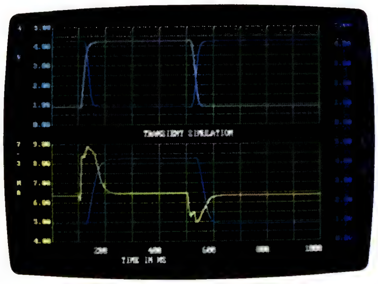

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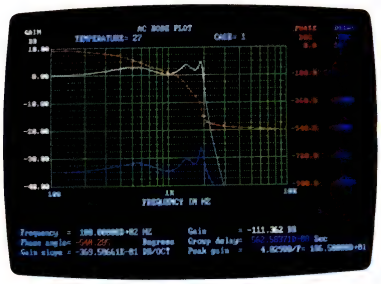
CIRCLE NO 122

- Transient, AC, DC, and FFT routines
- Op-amp and switch models
- Spec-sheet-to model converter*
- Printer and plotter* hard copy



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CALENDAR

Unix Expo, New York, NY. National Expositions Co, 49 W 38th St, New York, NY 10018. (212) 391-9111. October 27 to 29.

Hands-On Expert Systems Design and Development (short course), Anaheim, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. October 27 to 30.

Hands-On Graphics Programming Using GKS/VDI Tools (short course), Boston, MA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. October 27 to 30.

Designing Signal Processors with DSP and Bit-Slice Chips (short course), Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 3 to 6.

Hands-On Microprocessor Software, Hardware, and Interfacing (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 3 to 6.

Advanced SMT Design Techniques (short course), San Jose, CA. Surface Mount Technology Plus, 1786 Technology Dr, San Jose, CA 95110. (408) 943-0196. November 16 to 17.

Designing Signal Processors with DSP and Bit-Slice Chips (short course), Anaheim, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 17 to 20.

9th Interservice/Industry Training Systems Conference, Washington, DC. Ralph Nelson, ADPA, Rosslyn Center, Suite 900, 1700 N Moore St, Arlington, VA 22209. (703) 522-1820. November 30 to December 2.

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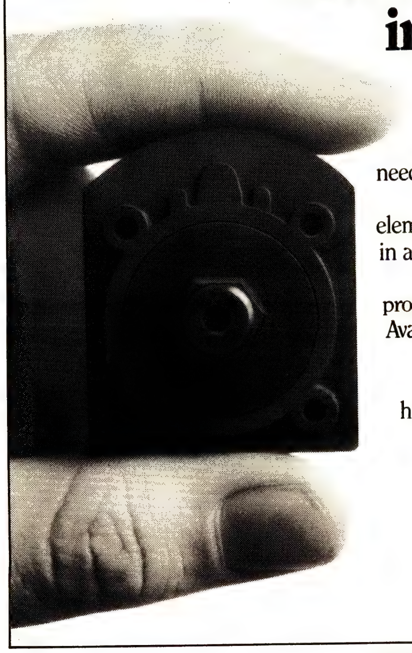
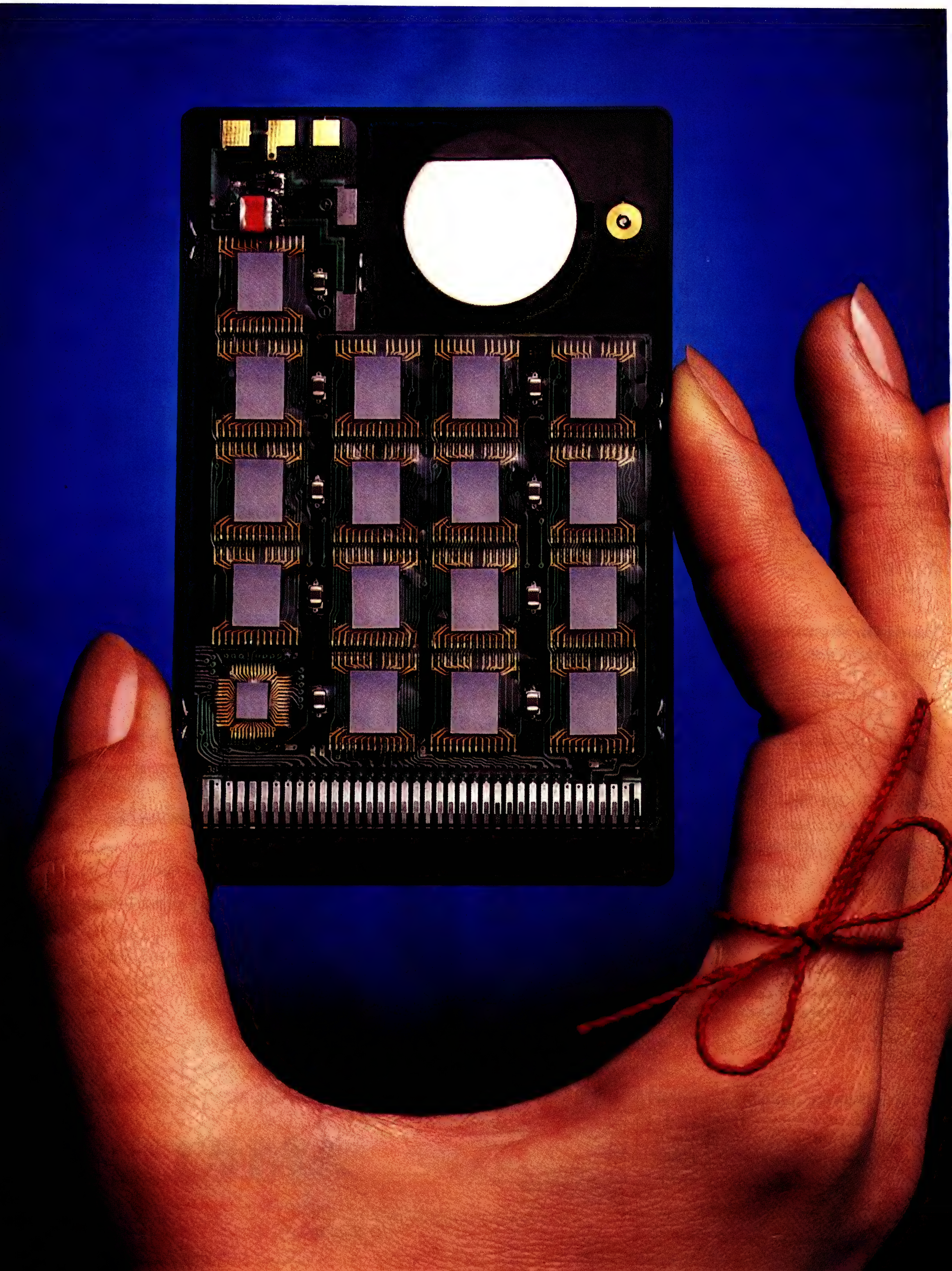


CIRCLE NO 8



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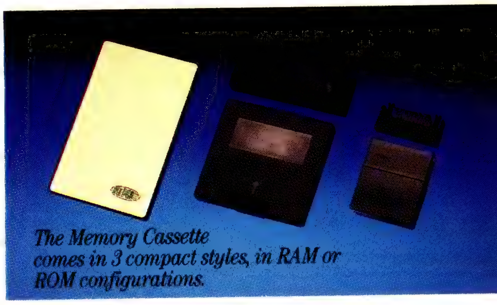

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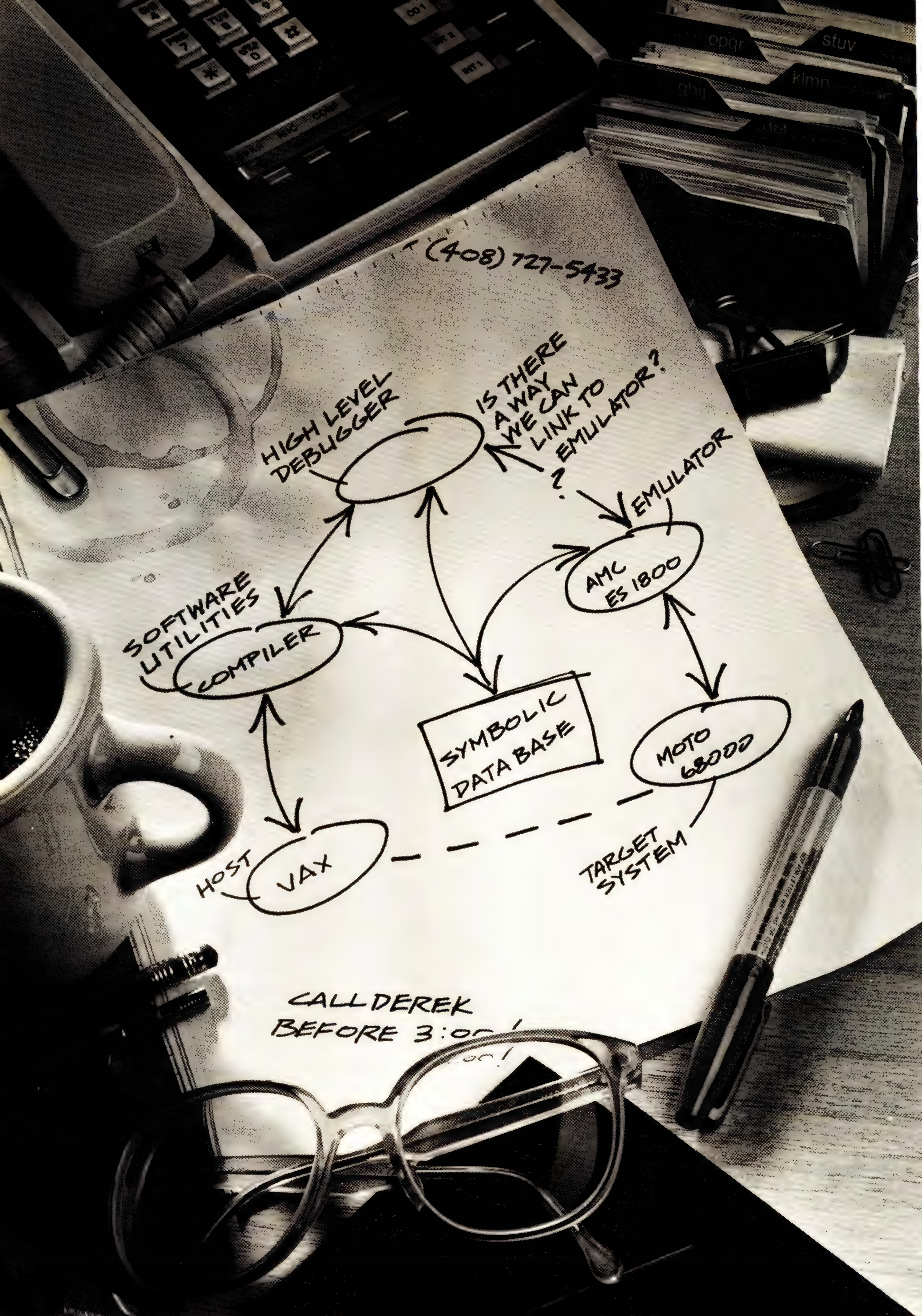
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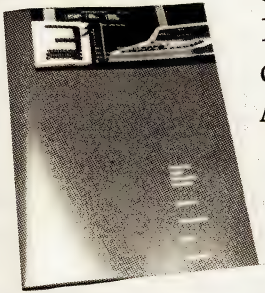

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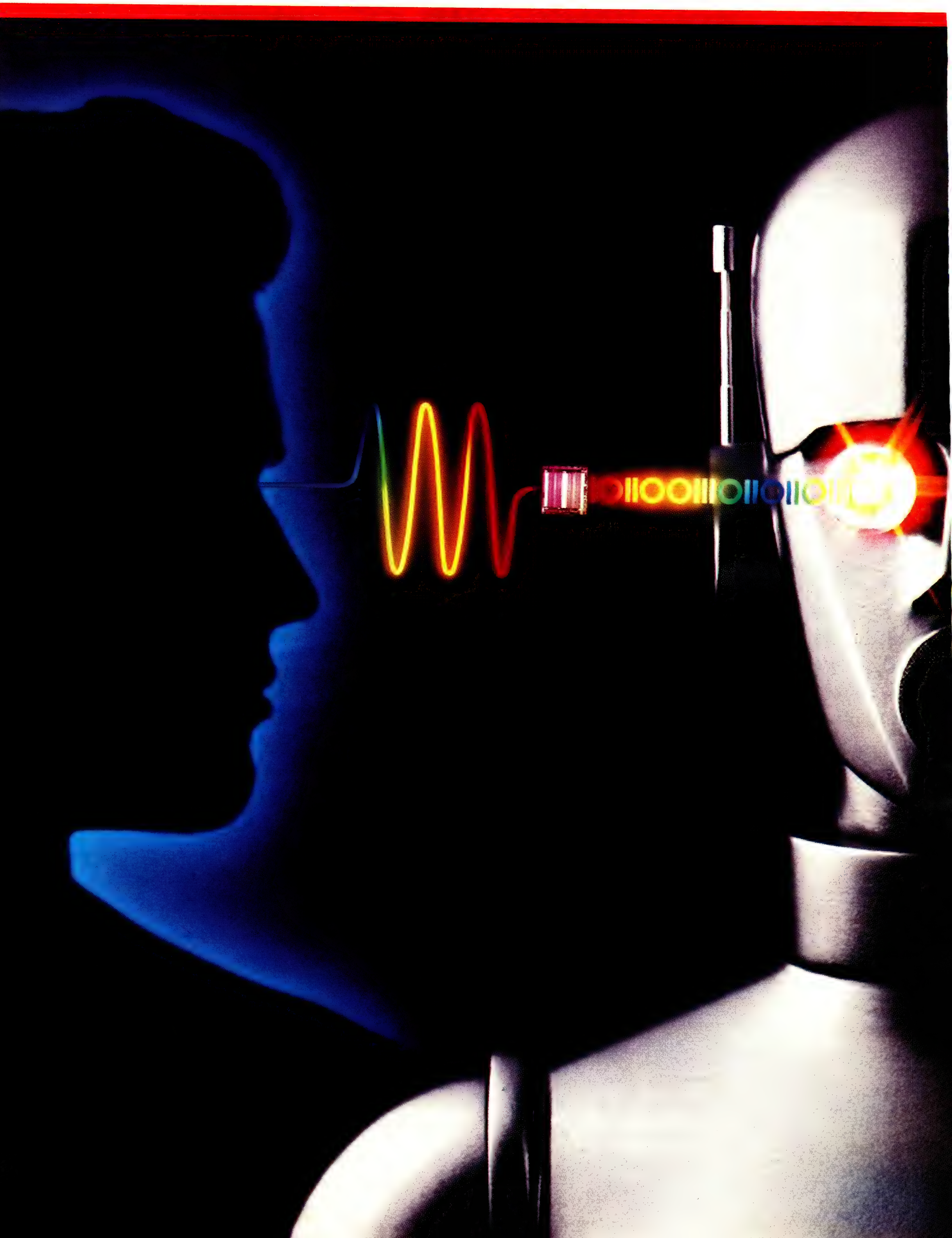
CIRCLE NO 125

High-resolution conversion



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10-bit CMOS serial ADC.

The CDPHC68A2 is selectable for either 8- or 10-bit resolution and has an 8-channel multiplexer allowing up to 8 channels of inputs. The device can be used directly with our CDP68HC05C4, C8 or D2 microprocessors or other similar SPI (Serial Peripheral Interface) buses.

8-bit CMOS R-2R video-speed DAC's.

These CMOS/SOS digital-to-analog converters operate from a single 5V supply at video speeds and can produce "rail-to-rail" output swings. Typical update rate is 50 MHz. Settling is fast (20 ns typical) to 1/2 LSB. "Glitch" energy is minimized by segmenting and bar graph decoding of upper 3 bits.

High-speed op amp.

Specially designed for use with data converters, the CA3450 op amp has excellent speed and transmission line driving capabilities.

For 10-bit accuracy, it settles to within 1/2 LSB in 40 ns with a 2V input signal. And it can drive up to four 50 ohm transmission lines.

ADC's	Res. Bits	Conv. Rate Hz	Power Diss. (MW)	Pkg. Leads	1K Price
CA3304E	4	20M	30	16	2.95
CA3304AE	4	25M	35	16	4.50
CA3306CE	6	10M	65	18	5.50
CA3306E/3306AE	6	15M	70	18	6.25/11.25
CA3318E/3318CE	8	15M	150	24	38.50/24.00
CA3310E/3310AE	10	150K	15	24	6.00/8.00
CDP68HC68A2E	10	10K	15	16	3.75
DAC's					
CA3338E/3338AE	8	50M	100	16	6.00/8.40
OP AMP	**UGBW Hz**	**Slew Rate (X10)**	**I_{OUT} MA**	**Pkg Leads**	**1K Price**
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Get on line

Years ago computer-industry specialists predicted a paperless future, and the paper industry saw the possibility of rapidly dwindling markets. They need not have worried. Often when someone buys a personal computer, they also buy a printer. They ought to buy a modem too.

For all the talk about high-speed phone-line communications, it's surprising that more people don't take advantage of MCI Mail, Western Union's Easylink, the Source, and other such services. During the Iran-Contra hearings in Congress, for example, I thought I'd send a letter to several elected officials. Well, it was a surprise to find that the White House isn't equipped to accept electronic mail. Neither are our Massachusetts senators. If you're an electronic-mail subscriber, try sending a message to your congressional representative or your senators. I'll bet they aren't connected to the system either. Some people just like paper.

However, many businesses realize that some communications are best handled by electronics. Texas Instruments operates its own electronic bulletin board for digital-signal-processing (DSP) information. You can reach it by calling (713) 274-2323. You're then able to download TMS320 DSP programs as well as exchange programs with other users. You can get other sorts of product information as well: Intersil furnishes on-line information about its products. Just have your computer dial (800) 345-7335, or (203) 852-9201 in CT, and type in the response code GEISIOAC. In the future I think we'll find more and more companies handling product inquiries, customer service, and routine messages by electronic mail. If you don't have a modem on your computer, this might be the time to consider buying one.

Although it doesn't take long to become familiar with electronic mail, you must pay attention to what you do. Several years ago, after typing addresses and part of a message into an electronic-mail system, I had to ask the system for help. Not receiving any assistance after three tries, I hung up my phone. Early the next day I got a call from one of the people I tried to contact. "Jon," he said, "I got the strangest message from you. All it said was, 'Gentlemen, this is to inform you . . . HELP, HELP, HELP.'" Electronic mail can get people's attention too.

Jon Titus

Jon Titus
Editor
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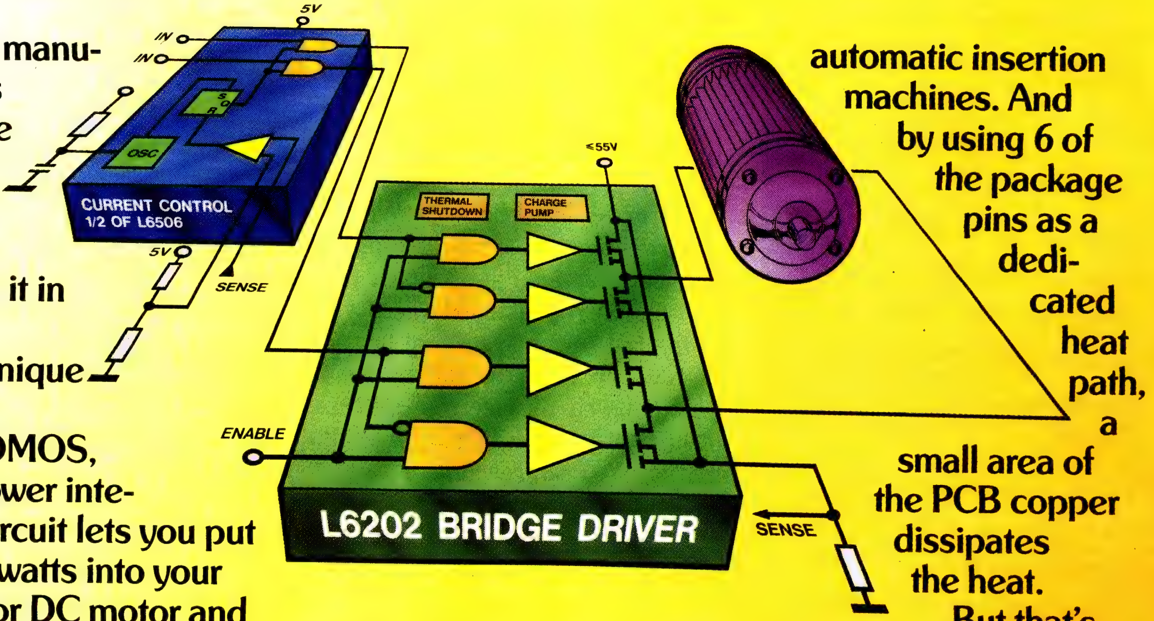

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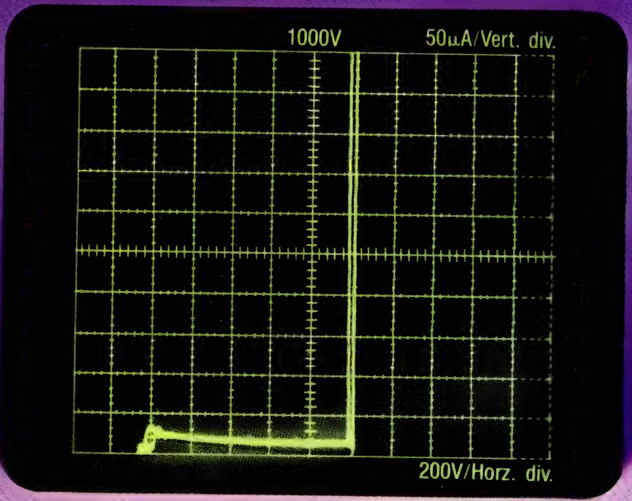

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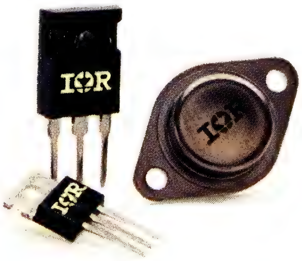

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Automatic test generators for PLDs clean up your logic designs

Charles H Small,
Associate Editor

If you're a design engineer who doesn't develop a comprehensive set of test vectors for your programmable logic devices (PLDs), you're not only passing a tricky problem on to the test department, you're also shortchanging yourself as a designer. At first glance, developing vectors for testing PLDs might seem like a problem for test engineers and not for designers. But if you submit a PLD design to a test-vector-generating program, the program's fault-coverage and testability report could identify areas where your design could be improved.

Several kinds of untestability can creep into your designs if you're not careful. First, if you don't do Karnaugh maps, you can leave redundant logic terms in your design. Redundant logic means that, in some cases, a failure of one of the redundant terms won't appear at the device's outputs because the other term will continue to supply the correct output. Although an undetectable fault may not keep the device from functioning properly in a circuit, devices with such faults are marginal and ought to be weeded out—except, of course, that you can't detect them. Often, you can render a device 100% testable simply by minimizing the logic equations that specify the PLD's design or by adding a test pin **(Fig 1)**.

Besides causing redundancy (which, in truth, you must sometimes design into a device to eliminate logic hazards), you can also create difficulties for test engineers by designing PLDs that can't be reset to a known state. The classic example is the D flip-flop used as a simple divide-by-2 divider. Even such a simple digital-logic element as this divider will baffle logic simulators and system-level ATE unless you've included a reset function that can force the element to a known initial state at the beginning of a test sequence.

Using an automatic test-generating program not only lets you develop a comprehensive set of test vectors, it also helps you create a testable device and identify any design errors or redundancies at the design stage. Test engineers can, of course, use the vector-generating programs to develop test vectors themselves if you do not, but they can't redesign parts for testability.

Note also that automatic test-vector generators can't guarantee 100% fault coverage in all cases, so you might sometimes have to accept a less thorough test. In the final analysis, you have to decide just how

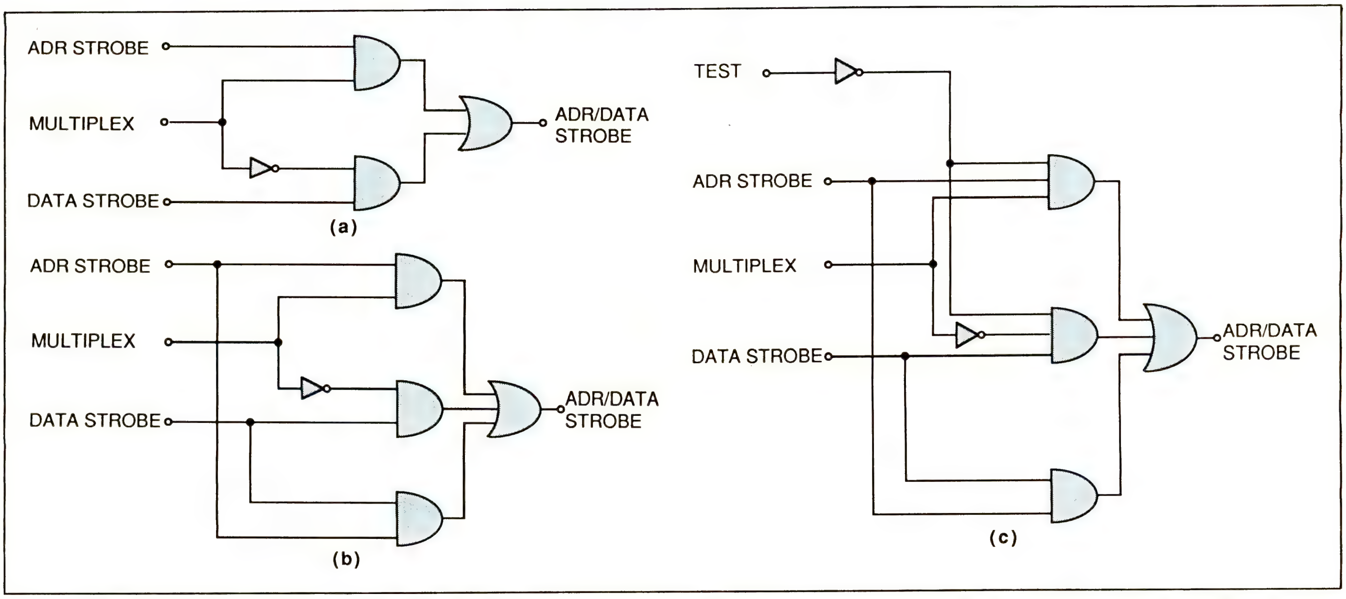

***Fig 1—To illustrate how a design** would evolve from a simple function, through a workable design, to a testable design, consider a simple multiplexer **(a)**. This initial design could exhibit a glitch because of the delay introduced by the inverter in the Multiplex line. A logically redundant AND gate **(b)** eliminates the glitch but renders the device less than 100% testable. An added Test pin **(c)** allows a tester to check both paths of the redundant logic. (Example courtesy Data I/O FutureNet)*

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CIRCLE NO 129

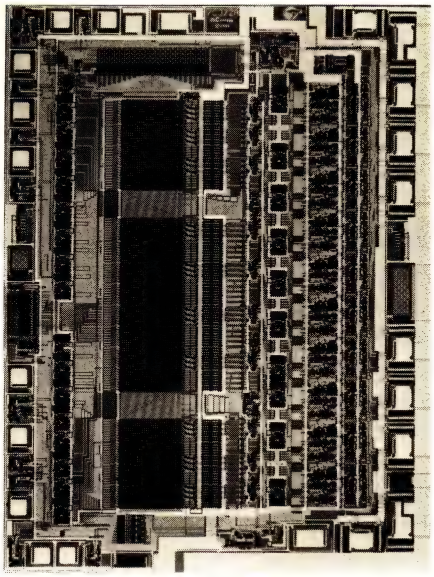
much quality you need. You must determine the minimum acceptable quality level (AQL) you can afford to purchase in terms of extra engineering time, manufacturing steps, and test equipment.

Although you, as a design engineer, can use vector-generating programs to your benefit, the programs were not developed as design aids. Rather, they were developed for test engineers, who have been clamoring for a method of performing device and in-circuit testing of PLDs that's as easy to do as testing nonprogrammable parts. Test engineers can generally get canned device tests for nonprogrammable parts (except for the very newest parts) from their ATE suppliers. That way, they don't have to depend on input from the design department.

Fuse-programmable PLDs, however, defy this handbook-jockey approach for two reasons: First, they are untestable at incoming inspection until programmed, and second, after programming, each design has a different function. Further, it's not uncommon for the function of a PLD to change and for the part to be reprogrammed during the life of a product. The test-vector generators attempt to give test engineers a test suite for programmable parts, so they don't have to consult the designer.

Curiously, PLD-programmer makers report that a considerable fraction of PLD users do little or no testing of PLDs and do not take advantage of the functional-test capabilities that virtually all PLD programmers have as standard features. This low degree of testing is curious because of the relatively low AQL (acceptable quality level) of PLDs compared with other ICs. For example, Japanese dynamic RAMs exhibit failure rates of 50 to 75 ppm. Early PLDs, on the other hand, had only 90% programming yields—an astronomical 10,000-ppm failure rate.

Granted, PLD makers have taken steps to improve their manufacturing processes and have incorporated test circuitry on their PLDs that can be checked before they ship the parts. But, unless you first test your PLDs after programming, then burn them in, and finally retest them after burn-in, the PLDs will still exhibit higher failure rates than do other digital ICs.



There's a lot more to a PLD than its fuse matrix. *In this microphotograph of a 22V10, the fuse matrix comprises the dark, rectangular areas just to the left of center. Simply verifying that the fuse matrix has been programmed correctly is not a complete test of a PLD, because failures could exist elsewhere in the device. (Photo courtesy Cypress Semiconductor, San Jose, CA)*

Furthermore, PLDs passing through an assembly plant don't have the same statistical distribution of failures as do other digital ICs. Instead of failing at a uniform rate, PLDs tend to be very good for long periods of time. Then, suddenly, their failure rate shoots up for a short time, only to fall again. Perhaps the spells of low failure rates lull PLD users into thinking that their devices don't need thorough testing.

Don't confuse PLDs with PROMs

At the low end of the testing range are firms that, at best, simply check the programmed PLD's fuse matrix against the fuse map in the device's JEDEC file. These users could be confusing a PLD with a PROM. Checking a PROM's fuse map is exactly equivalent to checking every memory location and hence constitutes a complete check of the chip's functions. Checking a PLD's fuse map, on the other hand, verifies only a small fraction of the device's total circuitry.

Further up the scale are PLD users who take advantage of the test-vector extensions in the JEDEC file and the functional-test capability of most PLD programmers by downloading a set of so-called test vectors to the PLD programmer. That way, the PLD programmer can not only check the programmed device's fuse map, but also exercise the part at low (virtually dc) speed.

In many cases, however, these so-called test vectors are simply a set of vectors devised by the design engineers (perhaps with the aid of a PLD-simulation program) to verify that the programmed PLD responds properly to its expected inputs. This approach reveals the difference in mindset between design and test engineers: The design engineer looks for what goes right with a device; the test engineer looks for what goes wrong.

Vectors find hidden faults

Although you should never throw any vectors away—a complete set of test vectors generally includes the design vectors—you often need to supplement the design vectors with additional test vectors. You need the additional vectors in order to be sure that the chip not only works as expected but also that it doesn't have some hidden fault that will cause it to work in some unexpected way.

To understand why you need additional test vectors, consider a simple example. Imagine that you have designed a registered PAL device as a simple latch. Next, suppose that during programming not all of the proper fuses are cleared. Perhaps the PLD circuitry is defective and doesn't respond properly to a fuse-map check, or perhaps the programmer hasn't completely cleared the fuses, or perhaps even the fuses have grown back. Now, for whatever reason, the device has some feedback paths that have been left enabled from its registered outputs back into its AND-OR matrix. Instead of a simple latch, what you now have is really a sequential state machine.

The set of test vectors for testing a latch is very simple. However, a set of vectors that would check for every possible programming fault, and thereby discover the unwanted state machine, would be much larger.

Develop test vectors by hand

You can do a testability analysis of a PLD manually and develop a set of comprehensive test vectors by hand. The simplest and oldest PLD-design software package, Palasm, won't generate test vectors automatically, but it will check a set of manually developed vectors for fault coverage. But the regular, simple structure of PLDs virtually demands computer-aided test-vector generation.

At present, only three test-vector generators are available. However, several firms engaged in various aspects of programming and testing PLDs are readying additional test-vector generators now. You can expect that the number of such products on the market will have at least doubled by next year.

Two of the available programs, Data I/O FutureNet's PLDtest and Structured Design's TestPLA, run on computers as small as IBM PCs and generate functional-test vectors for PLD programmers. The third, Teradyne's Circuit Breaker, is a preprocessor for the firm's powerful digital simulator, Lasar. Circuit Breaker develops not only functional-test vectors, but also tests that verify the at-speed timing parameters of PLDs. This extra feature obviously suits the capabilities of Teradyne's high-speed-device and in-circuit ATE.

Model simulates PLD's behavior

The three programs begin their test-vector generating by analyzing the fuse map in a PLD's JEDEC file to set up a computer model of the specified PLD. The model simulates the device's behavior after programming. In other words, the programs don't depend on any information from the designer other than the bare minimum necessary to program the parts.

Many things can go wrong with a PLD. But the test-vector generators described here all base their fault analysis on so-called stuck-at-one (SA1) and stuck-at-zero (SA0) faults. Computationally, it's easy to temporarily fix the output of a circuit-model element at a high or low level; other fault mechanisms would be harder to simulate.

Inserting SA1 and SA0 faults in a PLD simulation and checking to see whether the fault is observable at the device's outputs is a straightforward but tedious process, so it's best handled by a computer. The process consists of holding the output of each modeled logic element either in a high (SA1) or low (SA0) state regardless of the state of the modeled logic element's inputs. Then, the program looks back through the PLD's outputs to see if that fault will affect the output. The circuit simulator applies a set of test vectors to the altered PLD model and checks to see whether the simulated outputs differ from the correct expected outputs now that the PLD has been altered.

Although they can all handle combinatorial designs, the programs differ significantly in the way they handle sequential designs. Data I/O FutureNet's PLDtest achieves 100% fault coverage of sequential PLDs that have a preset function by using a simple, almost brute-force, approach. To get around the problem of initializing state machines and thoroughly exercising all possible paths through the state machine's states, PLDtest simply makes every other vector a preset vector.

Because of this scheme, PLDtest does not have to contend with the state machine's jumping from state to state, whether the state machine does so erroneously or according to design. Instead, the program produces a set of test vectors that causes the PLD programmer first to jam a known state into the PLD's registers, and then to apply an input vector to determine the PLD's behavior while in that known state.

The catch in this approach is easy to find: Many of the newest, fastest registered PLDs do not have preload capability. PLD makers have tended to omit the preload function from the first examples of each new, faster generation of parts. Data I/O FutureNet claims that this lack of preload is a temporary phenomenon. The firm adds that PLD users have made their need for testable PLDs (ones having the preload function) very clear to device makers, and that future, fast registered PLDs will incorporate the preload function.

For more information . . .

For more information on the PLD test-vector generators described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Data I/O FutureNet
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Circle No 701

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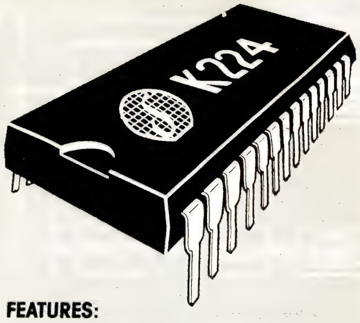

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PLDtest handles a wide range of PLDs. The firm expanded coverage recently, for example, to include 16 input-registered and XOR PLDs. The IBM PC version of the program costs $1995; the VAX/VMS and Unix versions sell for $3495.

Structured Design's $895 TestPLA handles 36 common 20- and 24-pin PLDs, including the 20RA10. The firm claims the program can generate test vectors for sequential PLDs that don't have the preset function. Like other test-vector generators, it reports the percent of fault coverage and announces the total number of detected and undetected faults. The program can also detect redundancy in your design. Besides offering an IBM PC version of the program, the vendor sells a version that runs on the DEC VAX under VMS.

Teradyne's $50,000 Circuit Breaker works with the AMD 22V10, the Signetics 82S105 and 82S167, and 10 MMI PALs. Each device model costs $2000, and you also need a license for Lasar version 6 ($25,000 to $280,000, depending on the computer).

Circuit Breaker sets up a device model that includes programmable delay elements in critical circuit paths. These delay elements do not model any of the actual functions of a good PLD. They exist to simulate process and programming faults that cause degraded signal paths and slow logic-gate operation. Thus, the program can check that timing problems, as well as functional problems, are observable.

Not all PLD manufacturers think that their devices require a custom set of test vectors. Altera, for example, has no test-generation software in its proprietary PLD-design package. Nor do its proprietary PLD programmers have any test capability. The firm maintains that its UV-erasable EPLDs (erasable PLDs) are "100%" testable at incoming inspection with a standard test.

One standard test for EPLDs is to program the windowed devices as counters and then run them at high speed on a device tester. If the devices count sucessfully, you then erase them and put them in stock. The prohibitively long write/erase cycles of UV-erasable parts precludes exhaustive testing and allows only this approach.

You may well question whether this approach yields an adequate AQL. Off the record, users report no problems with Altera devices. But these same users employ the windowed devices only for engineering development and plan to use one-time-programmable (OTP), nonwindowed devices in production. Thus, at least for some EPLDs that are in fact "nonerasable" (they come in packages that prevent erasure), you may still need custom test vectors.

Electrically erasable PLDs (EEPLDs), on the other hand, could allow standardized, more exhaustive testing at incoming inspection because of their shorter write/erase cycles. Such tests would require expensive, high-speed testers because even the relatively simple functional-test programs running on low-cost device programmers can take several minutes to execute.

In connection with incoming test of erasable PLDs, it's interesting to note that the test-engineering community would like the ATE manufacturers to write software that would allow ATE to both program and test PLDs. That way, manufacturers could eliminate the PLD programmer and its attendant device-handling step. Certainly, powerful device testers have the hardware to impress programming voltages and fuse-map files on a PLD; what's lacking is the software. Whether ATE companies want to take on the burden of supporting the rapidly changing and expanding field of PLDs is a question that only time will answer. **EDN**

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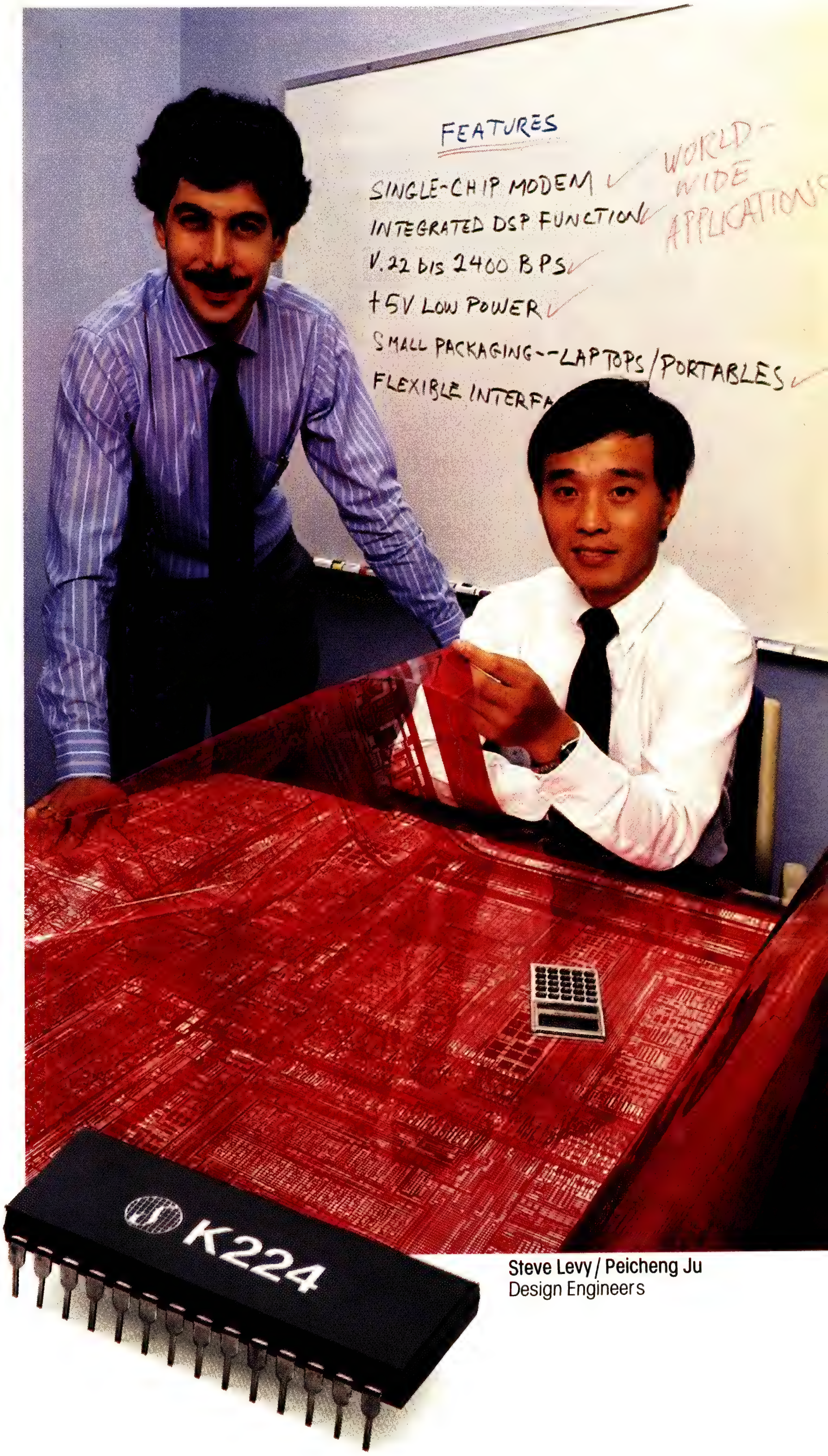

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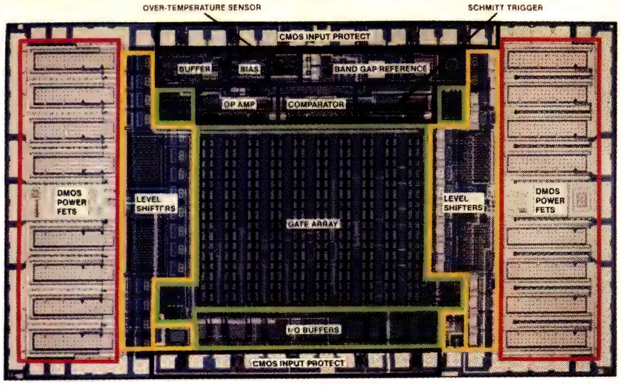
The MPD8020 does for power IC designers what gate and linear arrays do for low voltage digital and linear ASIC designers, fast turnaround at reasonable cost. MPD8020 wafers are held at the last step before metallization. After the customer specifies the interconnect pattern, Micrel turns each IC into a proprietary smart power ASIC. And Micrel does all this for about one-sixth the cost of a custom IC. Further, as your needs grow, Micrel can quickly and economically change your semicustom chip into a full custom chip for even greater cost savings.

A single +5 volt to +15 volt supply powers the logic and analog circuitry while the high voltage portion functions

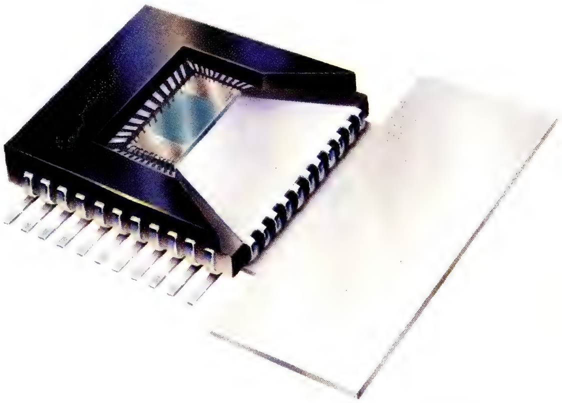


The MPD8020 uses Mixed CMOS/DMOS/Bipolar Technology to provide the user true monolithic smart power management.

operate at +10 to +100 volts. The chip can also derive the +15 volt analog/digital supply from a 24V, 48V, or 100V high voltage supply. Also, an internal voltage pump can be used to drive the high side gates of the power N-channel DMOS FETs at 15 volts above the +100 volt supply for rail-to-rail high voltage switching.

Kits for Your Breadboard and Design Assistance.

Two MPD8020 development kits are available from stock. MPD8020 Kit Part #1 demonstrates the operation of several analog SSI and MSI circuits. Price is $20 for this 40 pin DIP imprinted with eleven commonly used analog circuits. Kit Part #2 demontrates digital SSI and MSI circuits. Price is $15 for this 40 pin DIP containing eight revealing digital circuits used to check speed and digital timing characteristics.



The MPD8020 can be packaged in a 44 PIN JEDEC PLCC with an integral heat sink, 16 to 48 PIN DIPs, or single in-line power packages. Dice are also available for hybrid manufacturers.

Micrel also offers customers help from our CAD systems and CAE simulations (including SPICE, HILO, and TIMVER) as well as our fabrication and test group.

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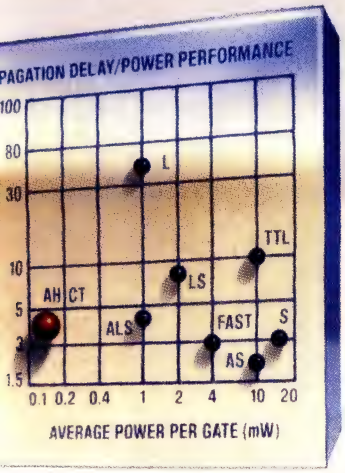

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SEPTEMBER 1987

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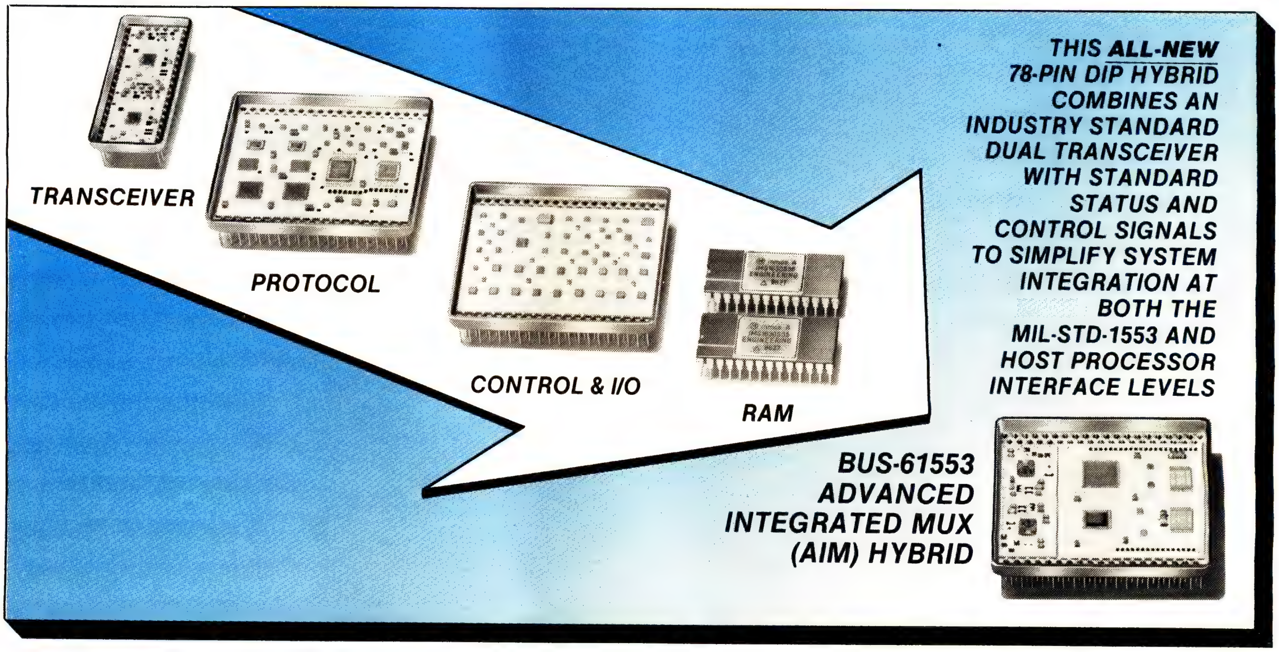

THIS ALL-NEW 78-PIN DIP HYBRID COMBINES AN INDUSTRY STANDARD DUAL TRANSCEIVER WITH STANDARD STATUS AND CONTROL SIGNALS TO SIMPLIFY SYSTEM INTEGRATION AT BOTH THE MIL-STD-1553 AND HOST PROCESSOR INTERFACE LEVELS

DDC announces the BUS-61553—a NEW STANDARD in MIL-STD-1553 devices. Containing a low power Dual Transceiver, complete Bus Controller (BC), Remote Terminal Unit (RTU) and Bus Monitor Terminal (MT) protocol, a powerful Memory Management/Host Interface IC and a full 8K x 16 bits of static RAM, the **BUS-61553, ADVANCED INTEGRATED MUX (AIM)** Hybrid is a complete, stand-alone dual-redundant MIL-STD-1553 interface. In fact, with a footprint of only 2.1" x 1.9", **DDC's BUS-61553 is the SMALLEST, MOST INTEGRATED 1553 interface available.**

The concept is simple: integrate the most powerful components available into a single, complete system building block. Two proprietary custom ICs make up the BUS-61553's BC/RTU/MT Protocol and Host Interface sections. Current DDC users will recognize the first as the heart of the BUS-65610 Intelligent Terminal and the second as the basis of the BUS-66300 II series Monobrid® (monolithic hybrid) respectively. The monolithic, low-power dual transceiver is also available separately forming the heart of DDC's BUS-63100 II transceiver series. And although 8K x 16 bits of low power (CMOS) "on-board" double buffered RAM is more than adequate for most applications, control I/O is provided for memory expansion up to a full 64K x 16 utilizing the internal memory or external RAM alone.

The BUS-61553 is fully compatible with available MIL-STD-1750 and other off-the-shelf CPUs. In fact, by assuming host CPU interface-maintenance and memory management "housekeeping" responsibilities, the BUS-61553 actually reduces CPU overhead, leaving the host free for other system-related functions.

By incorporating industry-standard DDC components, the AIM Hybrid represents a proven, extremely flexible solution with a host of support tools already available. It is ideal for applications requiring an inexpensive low power component that minimizes precious PC-board real estate usage while providing inherent reliability. **For additional information call toll-free: 800-DDC-1772.** ☐

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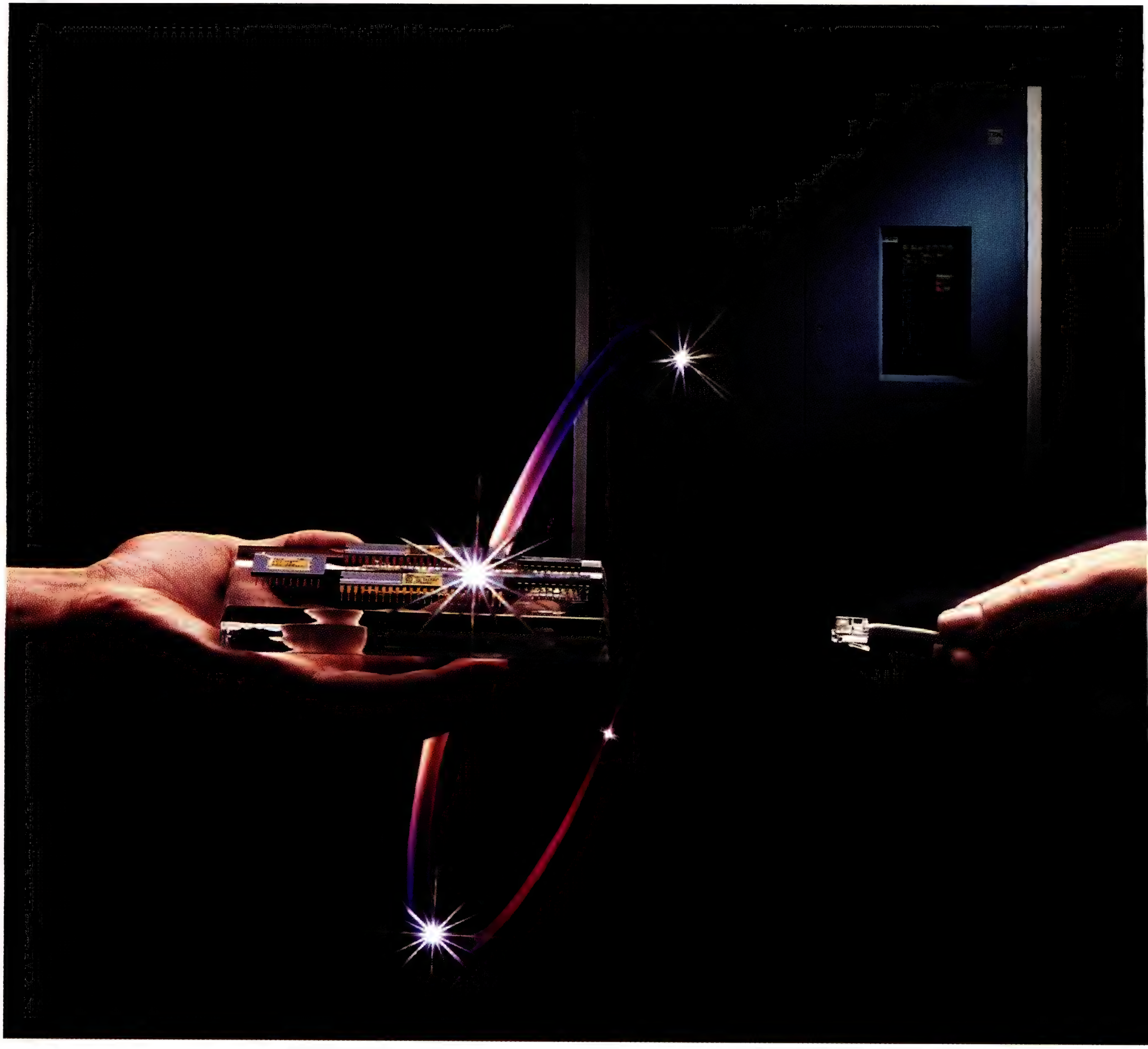

Only the TMS380 Chip Set from Texas Instruments is tested and verified with IBM. That frees you to concentrate on the important business of making your products market winners.

Industry observers agree: The IBM® Token-Ring Network is captur
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dia-access and software levels."**
t is Howard S. Charney, senior vice
ident of 3Com Corporation, stating

the chief reason for turning to TI first when designing-in token ring connectivity. You know your TMS380-based product will be 100% compatible with IBM and industry standards.

As a result, you avoid any problems of validation, verification, or long development time. You gain time to add product enhancements that can mean a competitive edge in the marketplace.

Martin Sinnott, director, Dayton Development Center of the NCR Corporation, sums up the advantage this way: "We offer the very highest level of interoperability with the IBM Token-Ring Network via TI's TMS380 Chip Set and our own software."

An integrated solution for "open" systems

TI's TMS380 Chip Set begins with a 40-million-bits-per-second DMA interface. This provides efficient connection to high-speed microprocessors such as Intel's 80X86 and Motorola's 680X0 families and open-system buses like IBM's Micro Channel™ and Apple's NuBus™

Having built-in software jointly copyrighted by IBM and TI, the TMS380 provides all IEEE 802.5 media-access control processing, including on-board network-management services *(see box)*. In addition, the TMS380 provides capability for message-buffer expansion and higher layer protocols, such as IBM-compatible IEEE 802.2 Logical Link Control (LLC), available from TI.

The TMS380 completes your connection to the IBM Token-Ring with physical-layer interface circuits that provide clocking, data reception and transmission, and ring-insertion control.

Opening the way to internetworking the TMS380 facilitates the design of token ring bridge and gateway products.

Good news about cost

Another reason to choose the TMS380 is that the cost of connectivity is coming down. The chip set is available now at a suggested resale price under $100.00 (quantity 100).

Reliable network management

"We have designed our ProNET®-4 product using the industry-standard TI TMS380 Chip Set. In addition to normal data-communications functions, the chip set provides power-up self-test as well as network-management frames for automatic error detection, parameter services, and reconfigurations. The net effect is reliable, manageable network operation."

Howard Salwen,
Chairman and Founder, Proteon, Inc.

The TMS380 reflects the influence of TI's MegaChip™ Technologies. These are the skills and disciplines acquired through ongoing development of high-density circuits which generate advances in semiconductor design, processing, manufacturing, and service.

These technologies are having an effect on other LAN standards. For example, TI has developed the SN75061/62 single-channel drivers/receivers that can easily be configured for use with StarLAN IEEE 802.3 1BASE5 networks. These new devices perform data transmission/reception and minimize transmission-line noise. The SN75061 is ideally suited to 1BASE5 stations; the lower-power, lower-cost SN75062, to hubs.

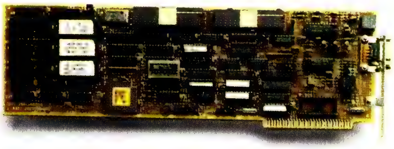
For more information on the broad TMS380 support, turn the page.

Comprehensive support from TI speeds TMS380 design-in.

TMS380 Design-in Accelerator Kit
TMS380 Adapter Chipset User's Guide
Local Area Network Products
Texas Instruments
TMS380 Token Ring Adapter Bring-Up Guide

To help you with everything from token ring adapter-card prototyping through communications-protocol development and systems integration, TI makes available the comprehensive TMS380 Development Products Family.

Design-in Accelerator Kit includes hardware and debug software for completing a prototype token ring adapter: Three sample TMS380 chip sets, engineering debug software with User's Guide, and an interconnect schematic.



PC Adapter Card helps you develop software and analyze traffic on the IBM Token-Ring Network. It works in both the PC Family and PC AT compatibles and incorporates TI's new IEEE 802.2 LLC. The card comes with demonstration software as well as protocol-analysis software to help develop your communications protocol.

Test Wiring Concentrator (TWC) provides the mechanism for any station to be inserted on the ring and adds LEDs that indicate ring insertion.

TMS380 LLC EvaluationKit provides the hardware, software, and documentation required to evaluate the IBM-compatible IEEE 802.2 LLC software on your designs.

ASIC-LAN Tool Kit enables the fast development of highly integrated, differentiated, and compact adapters. The kit contains ASIC software macro building blocks and completed design examples. These support Adapter Memory Expansion and PC Bus Interface. The kit not only helps save board space, but also several months of system and hardware design.

TMS380 Bridge Design Kit contains one TMS38021 Bridging Protocol Handler, one set of Bridge Options Adapter Software, and a TMS38021 Bridge Application Report to help you develop bridge or gateway products.

Token Ring Seminars are conducted on request at TI Regional Technology Centers or at your site. A two-day

workshop includes an introduction the TMS380 Chip Set and hands-o experience in the lab. A one-day TMS380 Advanced Topics Worksho provides an understanding of the extended LLC interface on the TMS3 and provides insight into bridge applications.

For more information on TI's TMS380 Chip Set, call TI's hot-line number, **(713) 274-2380.** Or comp and return the coupon today to Texa Instruments Incorporated, P.O. Box 809066, Dallas, Texas 75380-9066.

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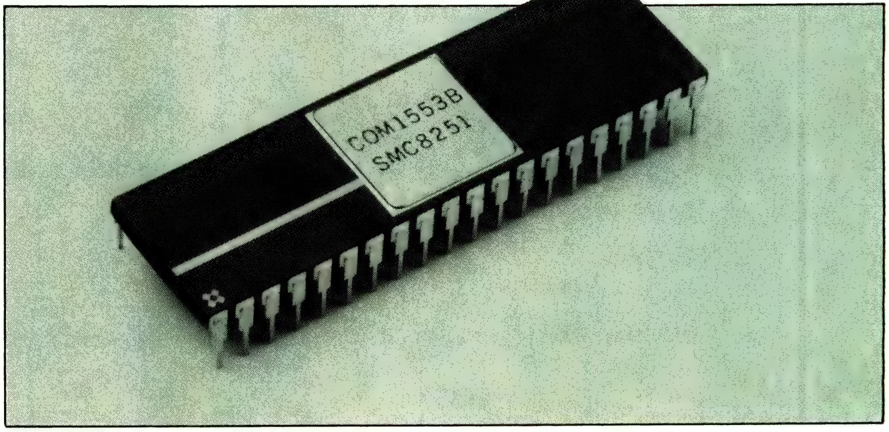
TEXAS INSTRUMENT

VLSI support chips let you use the 1553B bus in industrial applications

Peter Harold, *European Editor*

Your industrial networking applications may now be able to reap the benefits of the MIL-STD-1553B bus: Manufacturers have begun to introduce VLSI chips that support communication over the 1553B data bus, yet cost only $100 to $500. Many of the attributes of the 1553B bus that have contributed to its widespread use in military avionics systems—for example, its command/response protocol, high noise immunity, and dual-redundant bus architecture—also make it suitable for use in the harsh electrical environments encountered on factory floors and in industrial process plants. In addition, the architectures of this latest generation of VLSI devices let you interface the devices easily to µP-based systems.



Available in a 40-pin DIP *or leadless chip carrier, the COM-1553B currently represents the least expensive VLSI solution for implementing 1553B bus-controller functions: The DIP version sells for $97.55 (100).*

For nearly 10 years, the MIL-STD-1553B serial data bus has proved itself in military aircraft by providing a reliable communications link between onboard computers, weapons systems, and flight-control systems. Although silicon support for the 1553B bus has been available for several years in the form of both hybrid and VLSI devices, the high cost of processing these parts to military requirements has precluded the widespread use of the bus in industrial applications. At the same time, the lack of widespread industrial use of the chips has prevented the chip prices from falling.

Field-bus proposal

Recent developments in Europe and elsewhere may help to break this loop, however. The IEC (International Electrotechnical Commission) has set up a working group (SC65C WG6) to define a field bus for use in manufacturing-automation networks. The field bus will provide communication between sensors, actuators, and programmable logic controllers at the industrial-plant level. The field bus is the lowest level of manufacturing-automation networking. It is linked, through suitable gateways, to a MAP (Manufacturing Automation Protocol) network, either directly or by way of localized carrierband mini-MAP networks or subnetworks **(Fig 1)**.

The field bus will have to be a low-cost, real-time serial data link that maintains a high level of transmission efficiency and data integrity. As Peter Burton of ERA Technology (Leatherhead, UK) points out, "The 1553B bus already meets many of these requirements—it has proved its immunity to electromagnetic interference in avionics applications, yet it can use low-cost, shielded twisted-pair cabling." He continues, "Although the 1553B bus is designed for short-range transmission at 1M bps, transmission at a bit rate as high as 500k bps over a distance of 350m has been demonstrated, and a 125k-bps, 2-km link is operational."

Burton notes that 1553B has political advantages, too—it's an open standard accessible to both users and vendors, and it already has component- and board-level support from several manufacturers in several countries.

Technically, however, 1553B will require some enhancements for use as a field bus. For example, the bus will have to have the capability of distributing power via the data-bus cable. Further, the 1553B bus length will have to be extended (albeit with a restriction on data rate), and the bus will have to incorporate intrinsic explosion protection. Other considerations currently unspecified in 1553B—for example, the coupling-transformer isolation voltage, connector type, and applicable industrial EMC (electromagnetic capability) and environmental standards—will also have to be specified.

If 1553B is adopted as the basis for the field-bus specification, the prices of support chips will un-

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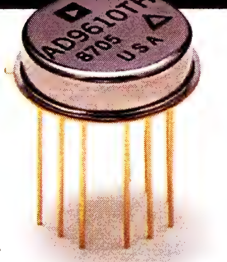

Because the AD9610 has 18ns settling to 0.1%, 3500V/μs slew rates and ample phase margin, it's perfect for pulse applications.

For more information, contact our sales engineers and ask about the AD9610 and its versatile evaluation board. They'll tell you everything you want to hear about this high-performance transimpedance amplifier.

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CIRCLE NO 62

doubtedly fall. After all, although a $500 bus-controller chip might be acceptable for a communications gateway or programmable logic controller, and a similarly priced remote-terminal-controller chip might just be affordable for intelligent terminals, such a chip would be too expensive for application in remote terminals that do nothing more than control a bank of valve actuators or interrogate limit switches.

Once industrial markets for these chips appear, however, chip manufacturers should find it easy to respond with lower-priced parts, because much of the cost of the military-grade devices goes into packaging costs and 100% visual inspection and testing. Consider, for example, Marconi Electronic Devices' MA805 remote-terminal-controller IC. As a military-grade part in a ceramic DIP, it sells for £247 (100); in the industrial-grade version, it costs £55 (100).

Particle accelerators

Industrial applications of 1553B are not merely draft specifications such as the field-bus spec—they also exist in reality. At the European Organization for Nuclear Research (CERN), which lies on the border of France and Switzerland, 1553B data buses as long as 2 km are used for data acquisition and control of the LEP (large electron-positron collider) and SPS (super proton synchrotron) particle accelerators. Depending on the bus length, the user can select transmission rates of 1M, 500k, 250k, or 125k bps. In the course of installing these systems, CERN developed 1553B bus-controller/remote-terminal cards for Camac, VME Bus, G64-bus, and IBM PC/AT-bus computer systems. All of these cards are based on Standard Microsystems Corp's COM-1553B bus-controller/remote-terminal chip, but CERN also uses Marconi's MA805 chip for remote-terminal applications.

You can expect all the latest-generation 1553B-bus interface chips to handle most of the bus protocol automatically. They handle such functions as remote-terminal address recognition, examination of 1553B command words to determine the type of message transfer required, the correct sequencing of command and data words, and the automatic transmission of status words. In addition, these chips automatically check the incoming information for message errors.

In all of these interface chips, the interface between the chip and the 1553B bus is very similar. Virtually all the recently introduced 1553B

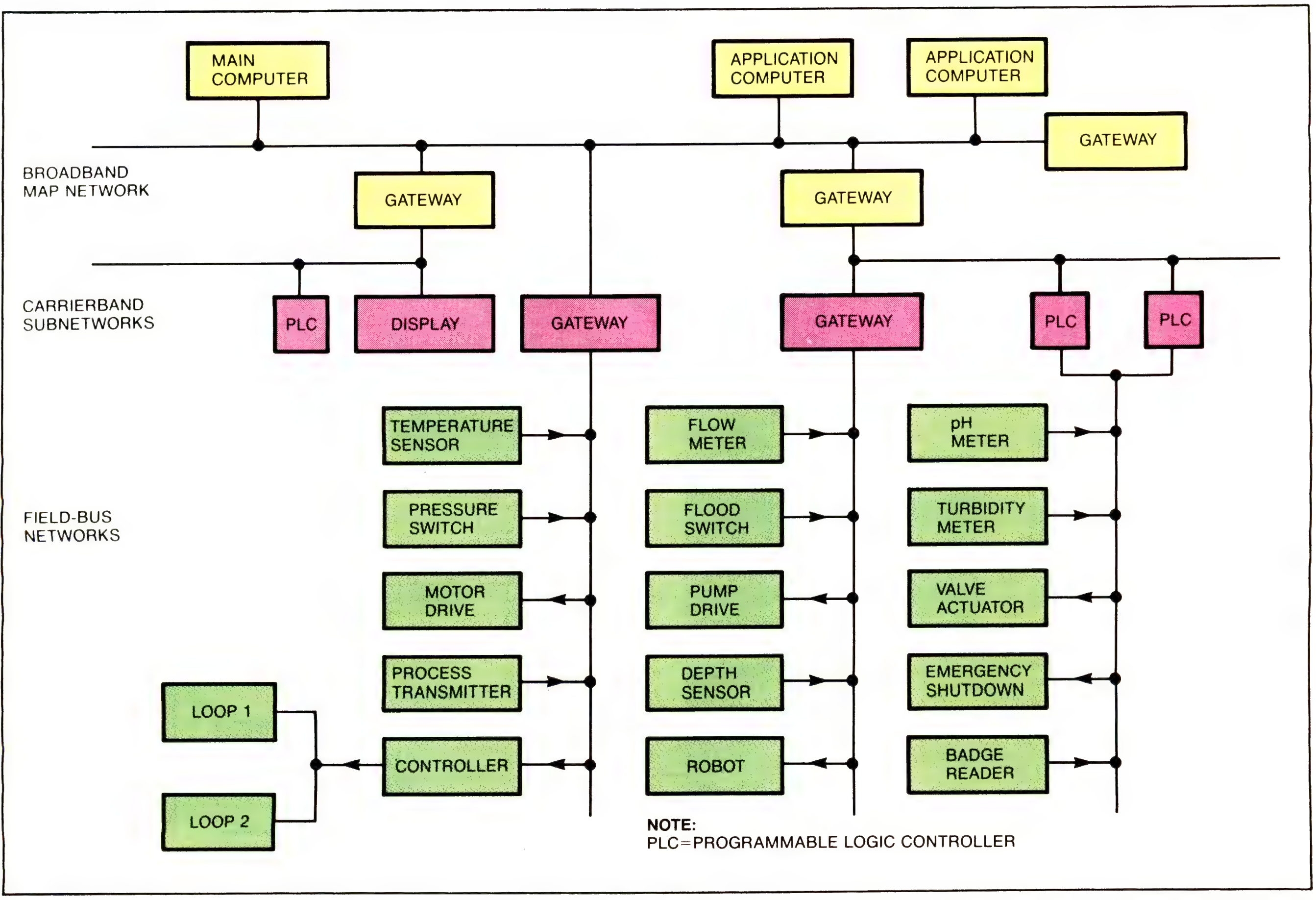

*Fig 1—**1553B is a strong contender** for use as the field bus in MAP applications, where its high noise immunity and low-cost cabling make it suitable for use in factory-floor and industrial-process environments. Gateways from local carrierband subnetworks or the broadband MAP network allow these networks to control and monitor field-bus activity.*

communication ICs incorporate the encoder/decoder required to translate data to and from the Manchester II biphase encoded format (the format for transmission over the 1553B bus). As a result, the 1553B side of these devices comprises only five signal lines—true and complement transmit-data lines, true and complement receive-data lines, and a transmit-inhibit signal. These signals directly drive a 1553B bus transceiver, which performs the voltage-level translation necessary to drive the coupling transformer that connects the bus-interface unit to the 1553B bus. On some ICs, this transceiver interface is duplicated, so it provides single-chip support for dual-redundant bus systems.

Virtually all the VLSI 1553B interface chips available are intended for interfacing to an intelligent subsystem, and they therefore have a μP-style subsystem interface. With these VLSI devices, as with any other communications IC (such as a UART or an Ethernet controller), it's an advantage for the communications IC to pass received and transmitted data to and from the subsystem with a minimum of host-processor intervention.

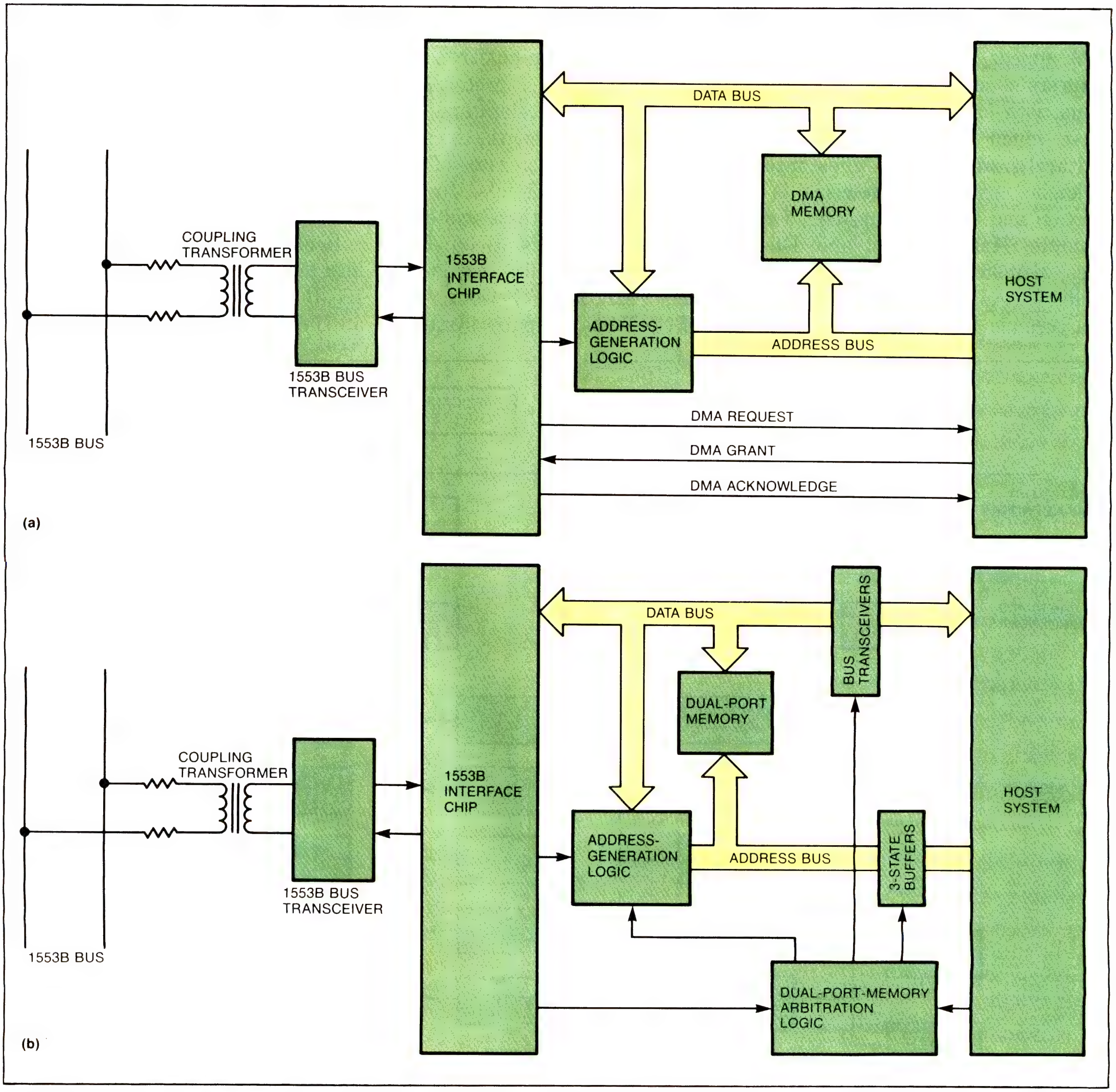

Fig 2—To minimize host-processor overhead, *most 1553B interface chips perform DMA operations to transfer data and commands to and from host-system memory* ***(a)****. You can further reduce the interface chip's disruption of host-processor activity by adopting the dual-port memory architecture shown in* ***b****. To assist in arbitrating dual-port memory access without endangering 1553B-bus data integrity, some interface ICs provide special flag outputs; others require arbitration-support chips.*

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Indeed, the 1553B bus has some special timing requirements that virtually preclude software control of the bus protocol. For example, the status word, which indicates receipt of an error-free message, must be transmitted by a remote terminal to the bus controller within 4 to 12 μsec after the end of the message transmission. It's unlikely that a host processor could check the incoming data for errors and provide a status byte within this time frame, but even if it could, the 1M-bps data rate and 20-bit word length specified in 1553B would require the error-checking program to run every 20 μsec, leaving the host processor little time to run its application program. As a result, error checking and status-byte generation and transmission are usually performed by hardware within the interface chip.

DMA and dual-port RAM

To minimize host-processor intervention, 1553B interface chips typically move data between the subsystem and the 1553B bus by performing DMA accesses directly to host memory. However, by adding a few 3-state bus buffers, you can often create a block of memory between the interface chip and the subsystem that operates as dual-port RAM **(Fig 2)**. A dual-port RAM interface further reduces host-system disturbance by eliminating the bus-arbitration and DMA cycles that a DMA technique requires.

United Technologies Microelectronics Center's (UTMC's) UT1553B-BCRT (a bus-controller/remote-terminal IC) and UT1553B-RTI (a remote-terminal IC) allow you to adopt either a DMA or a dual-port-RAM technique. Both devices feature an integrated address generator that provides the DMA addressing, so they eliminate the need for the external address-generation logic shown in **Fig 2.**

To perform DMA transfers, the UT1553B-BCRT uses standard DMA-request, DMA-grant, and DMA-acknowledge handshaking to gain control of the host system's data and address buses. To assist in determining when the host processor can access the RAM without corrupting the flow of data between the 1553B bus and the RAM, the BCRT has a memory-window ($\overline{\text{MEMWIN}}$) signal, which allows the host processor to determine periods of time when the BCRT chip will not require RAM access.

The UT1553B-RTI operates with simplified DMA-request/DMA-acknowledge handshaking. As long as the DMA acknowledge is received within defined time limits (14.9 μsec for transmit commands, 18.8 μsec for receive commands), 1553B-bus data won't be lost.

Because these interface chips have large memory areas (64k words for the BCRT, 2k words for the RTI) in which they can store or access data, you can minimize the frequency of host-processor intervention in the communications process. In fact, you can reduce this intervention to a few interrupt-driven service routines. These chips also allow you to partition message information within the memory. For example, in the remote-terminal mode, the BCRT allows you to store the data associated with any of the remote terminal's 30 subaddresses anywhere within the 64k-word memory area. The BCRT can then automatically buffer in memory as many as 128 incoming messages directed to each of these subaddresses.

In the BCRT's bus-controller mode, each 1553B bus message is controlled by a command block contained in RAM. Each command block contains the 1553B command word (or words), which set up the source and/or destination for the bus message; address pointers for transmitted and received data; and control information for selecting programmable functions within the BCRT (for example, for defining conditions that can interrupt the host processor). In addition, the command blocks contain pointers to both the preceding and succeeding command blocks, so you can set up complex message sequences by chaining command blocks together.

Chip maps data in memory

The RTI chip generates its memory addresses directly from the transmit/receive bit, subaddress, and word-count information in the

For more information . . .

For more information on the MIL-STD-1553B-bus support chips described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

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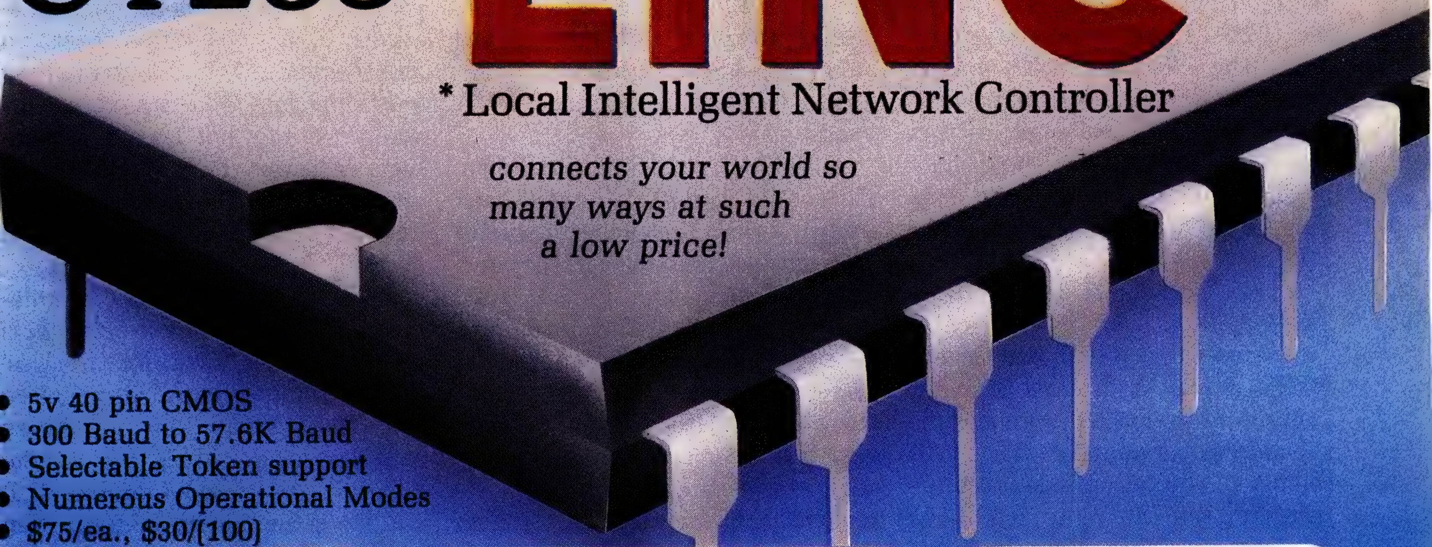

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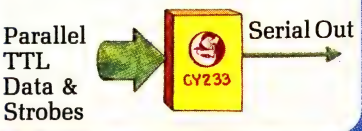
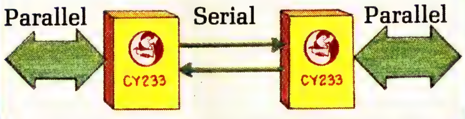
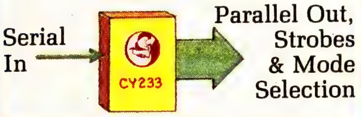


Wire-Saver



Serial to Parallel



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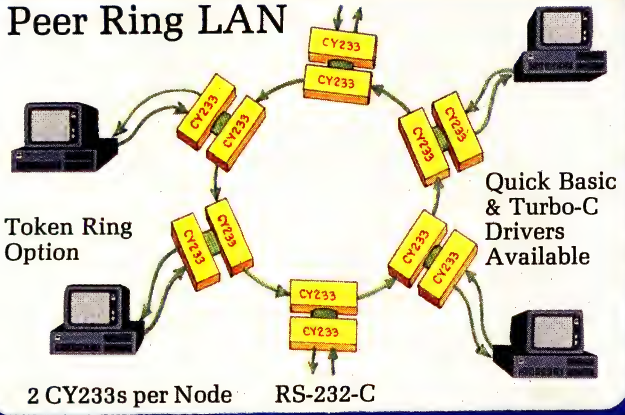

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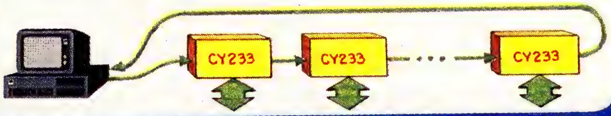

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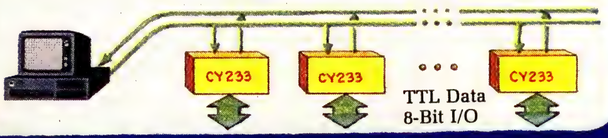
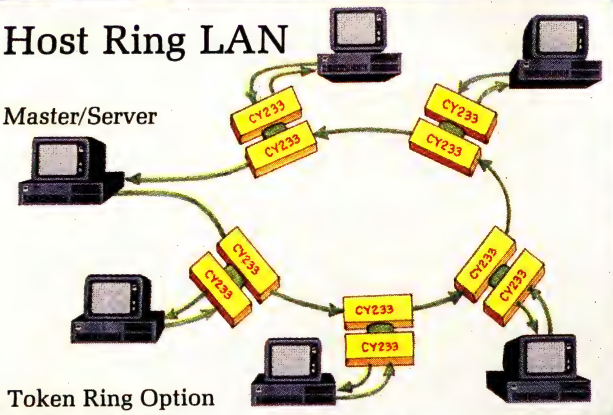


Host Ring LAN



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1553B-bus command word in order to provide separate 32-word receive and transmit buffers for each remote-terminal subaddress. However, UTMC's latest remote-terminal chip—the UT1553-RTMP—has an address generator that can perform DMA access to as much as 64k words of memory, and that provides much more versatile memory-mapping capabilities than those of the RTI.

RAM buffers

A base-address register in the RTMP points to a block of buffer pointers in the RAM. By using the subaddress contained in the 1553B command word as an index to these pointers, you can route 1553B-bus data to and from separate RAM buffers for each of a remote terminal's 30 possible subaddresses. Alternatively, you can route all the messages to a single buffer. You can also select the buffer size to be as large as 32k words. The relevant 1553B-bus command word, along with a time tag that allows you to determine when the message was received, is stored with each received message.

UTMC's interface chips clearly target application in intelligent subsystems that require an absolute minimum of host-processor intervention in 1553B-bus communication, and which require single-chip support for a dual-redundant bus system. In such applications, the relatively high cost of these chips—$825 for the BCRT, $543 for the RTI, and $573 for the RTMP (100)—may be acceptable. Bear in mind that these prices get you a military-grade part that operates over −55 to +125°C. All the UTMC parts are available in 84-pin PGA and surface-mount packages.

For more cost-sensitive applications, consider using Standard Microsystems Corp's COM-1553B bus-controller/remote-terminal chip, which sells for $97.55 (100) in a 40-pin DIP and $112 (100) in a leadless chip carrier. The price/performance tradeoff you'll face is that the COM-1553B requires more interface logic and greater host-processor intervention than do the UTMC chips, because the COM-1553B doesn't use an on-chip address generator to address subsystem RAM during DMA operations.

Although the COM-1553B provides DMA-handshake signals and control signals that indicate whether command, data, or control information is being transferred, you'll have to provide external logic to generate the memory addresses for this information. This logic will be more complicated if you want to partition the information in memory—for example, according to remote-terminal subaddresses. Rather than implement this interface in hardware, you may well opt to interrupt the host processor after each complete message is received and sort out the messages under software control. When it's in remote-terminal mode, the COM-1553B automatically appends the appropriate 1553B-bus command and the message's error-status register to the received data that it places in memory. When the COM-1553B is in bus-controller mode, you have to initiate all of its DMA operations via the host processor.

Harris Corp's HS3273 bus-controller/remote-terminal chip has capabilities similar to the COM-1553B's. However, although the HS3273 does generate part of its DMA memory address from its 5-bit word counter, it's currently available only as a military-grade part, and its price—around $500 (500)—doesn't suit it well to industrial applications.

Implement simple terminals

Without using too much external glue logic, you can also interface the COM-1553B or HS3273 to nonintelligent remote-terminal subsystems—for example, simple subsystems that interrogate a set of switch positions via 3-state buffers, or that drive simple actuators or relays via latches. It's also worth noting that Standard Microsystems' COM-1553B and Harris's HS-3273 support only a single 1553B bus transceiver, so to implement a dual-redundant bus system you must duplicate the chips. This characteristic may not be a disadvantage, however: In many industrial applications, the use of a dual-redundant bus would be considered overkill.

A lower-cost method of implementing a simple remote terminal is to use Marconi Electronic Devices' MA805 remote-terminal interface chip. The MA805 is also available as an industrial-grade component, the STF815P, which sells for £55 (100) and has a simple 16-bit subsystem interface that you can couple to subsystems having a range of complexities.

Chip is easy to use

The information that appears on the subsystem interface closely resembles the data transferred over the 1553B bus, so the device is particularly easy to use. The 16-bit words that the MA805 writes to the subsystem are either received 1553B command words or received 1553B data words. The words that the MA805 reads from the subsystem are either data words for transmission over the 1553B bus, or modifier words for the 1553B-bus status word. All these words are preceded by a control word that contains the 1553B command word's transmit/receive bit, its remote-terminal subaddress, and the current word count, as well as various flag bits. These flag bits indicate the nature of the next word (command, status modifier, or data) that will appear at the subsystem interface.

By latching this control word, you can create a subsystem address to or from which the command, status modifier, and data words can be transferred. In its simplest form, this address could enable latches and 3-state buffers to transfer parallel I/O signals; alternatively, you

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could use it to select separate memory areas for the various types of data.

The MA805 normally operates with simple DMA-request, DMA-grant handshaking. However, you can implement a dual-port RAM interface by adding the company's MA8055 subsystem-interface support chip. Although this chip currently costs £90 (100) in a military-grade version, the vendor intends to offer a lower-cost industrial-grade version. In conjunction with a few octal latches and buffers and two 2k×8-bit static RAMs, this device arbitrates dual-port RAM access on a message-by-message basis, without the risk of losing or corrupting 1553B bus traffic. In addition, it allows you to implement an 8- or 16-bit subsystem interface.

Two chips replace four

Marconi Electronic Devices' latest bus-controller/remote-terminal offering is a 2-chip set comprising the MA3690 and the MA3691, which both come in 48-pin ceramic DIPs. This 2-chip set replaces the company's earlier 4-chip set. When the chip set is in the bus-controller mode, each 1553B-bus transaction is controlled by a 4-word command block fetched from subsystem memory. This command block contains an instruction word, which defines the type of message transfer required and selects other programmable functions within the interface chips; the receive command word and/or transmit-command word, which define the source and/or destination for the 1553B message transfer; and an address pointer for the transmitted or received data.

Upon completing a bus transaction, the chip set indicates the success or failure of the message transfer by writing three report words to memory. These words include 15 single-bit status and error flags, plus the receiving or transmitting terminal's status word.

The Marconi chip set's command-block and error-reporting structures are similar to those of UTMC's UT1553-BCRT, and the chip set lets you perform simple command-block chaining. However, unlike the UTMC device, the Marconi device requires you to implement address mapping externally if you want to partition information in subsystem memory. The relatively simple subsystem interface provided on the MA3690/MA3691 does allow you to implement a nonprocessor-based subsystem (such as an emergency bus controller driven from a table of command blocks held in PROM) with relatively few external components. The biggest disadvantage to using the MA3690/MA3691 chip set in industrial applications is its £890 (100) price tag. Although this price may be justifiable in bus-controller applications, it's probably too high for widespread use in remote terminals. One reason for the high price is that the parts are fabricated for military use in radiation-hardened SOS (silicon-on-sapphire) technology. If you don't mind using four chips instead of one or two, consider using the company's 4-chip set, which provides functionality (except for the command-block chaining facility) similar to that of the 2-chip set, but is now available as an industrial-grade product priced at £80 (100).

Simple subsystem interface

Like Marconi, Micro Circuit Engineering Ltd produces a single-chip remote-terminal interface and chip sets for implementing bus-controller/remote-terminal capabilities. The MT32802 dual-redundant remote-terminal chip costs $600 (100) and is available in a 48-pin DIP or a 48-lead chip carrier. The device has a relatively simple subsystem interface comprising a 16-bit bidirectional data bus and dedicated control lines that indicate the nature of the information available on the bidirectional bus (for example, a valid command word, data word, transmit command, or receive command). The chip also provides single-line

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inputs, which modify various bits in the remote terminal's status word.

A variant of this device, the MT32807, has additional remote-terminal functions: It provides selectable data wraparound for test purposes, a readable status word, and broadcast-command recognition. It also has signals that allow you to connect it to the company's MT32015 bus-controller protocol chip. This 2-chip set provides bus-controller/remote-terminal capabilities. The MT32015, which costs $289 (100) and comes in a 64-pin DIP or 56-lead chip carrier, also presents a 16-bit bidirectional data bus and dedicated-control-line subsystem interface. If you merely want to implement a bus-controller function, you can couple the MT32015 to the company's MT32018 or MT32028 Manchester encoder/decoder chips, which cost $255 (100) each.

To effect a DMA interface to the subsystem, instead of having to use the host processor to manage the data flow, you'll have to add another chip to the system. The MT32603 and MT32604 subsystem-interface-controller chips provide DMA interfaces, including full address generation, to VME Bus and Multibus computer systems, respectively. They each cost $255 (100). (Because, architecturally, the VME Bus and Multibus closely resemble Motorola and Intel μP buses, you should have no difficulty in using the MT32603 and MT32604 to provide a direct connection to a subsystem based on one of these μPs.) The company also offers an interface chip for the ARINC-429 bus.

Modify bus operation

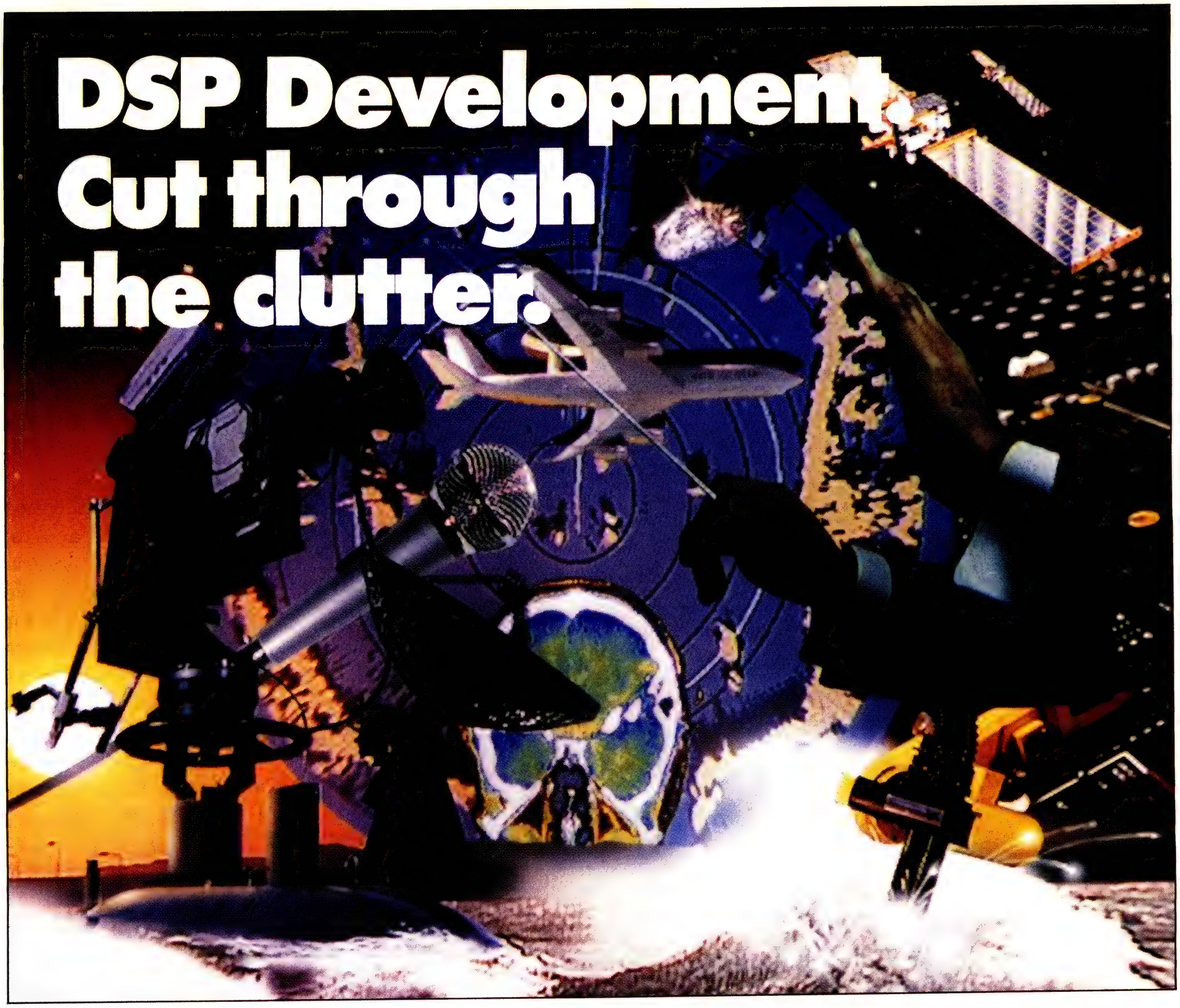
When choosing interface chips for industrial applications of 1553B, bear in mind that these applications may not necessitate strict adherence to the MIL-STD-1553B bus specification. For example, if you extend the bus length, you'll almost certainly have to operate it at data rates lower than 1M bps. However, the timing information quoted on most manufacturers' data sheets assumes that the interface chip has a clock frequency that provides the MIL-STD-1553B 1M-bps data rate. Fortunately, because all the interface chips discussed here are CMOS parts, chances are that they're also static parts, so reducing the clock frequency should result in a proportionate reduction in data rate.

One effect of using longer buses or lower-grade cabling is that the propagation delays in the cable may cause the remote-terminal response time to exceed the 12 μsec specified by MIL-STD-1553B. In this case, the receiving terminal will detect a message error and disregard the transmitted data.

Although reducing the chip's clock frequency may extend the timeout period before a message error is declared, it will also reduce your data rate. You may be able to maintain a 1M-bps data rate if you can extend this timeout period by some other means. For example, Marconi Electronic Devices' MA805 remote-terminal chip and MA3690/MA3691 bus-controller/remote-terminal chip set allow you to select one of four different timeout periods. The maximum timeouts are 64 μsec for the MA805 and 106 μsec for the MA3690/MA3691.

In addition, you may require that remote terminals be able to detect and report, via the status word, receipt of illegal commands to which they can't respond. (Strictly, 1553B requires the bus controller to know the capabilities of the system's remote terminals, so that these illegal commands will not be sent.) To assist in implementing this function, some interface chips provide an illegal-command input so that you can declare a command illegal. Typically, you can use an external PROM as a hardware look-up table to examine command words and provide this illegal-command input.

If you're already familiar with 1553B bus systems, you may note that several major manufacturers of 1553B interface products—for ex-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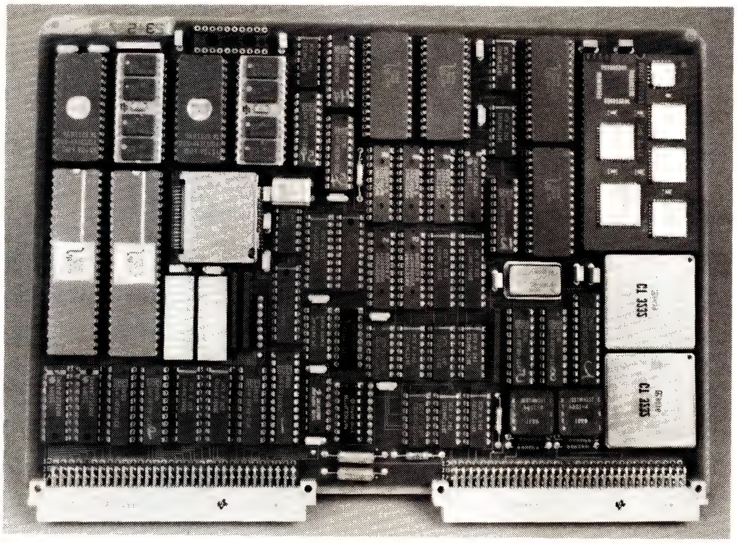

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CIRCLE NO 12

ample, Aeroflex Laboratories Inc (Plainview, NY), ILC Data Device Corp (Bohemia, NY), Marconi Microsystems Ltd (Portsmouth, UK), and STC-Components (Great Yarmouth, UK)—don't appear in this article. These companies concentrate on manufacturing military-grade hybrid components that are designed specifically to pack the greatest functionality into the smallest and most rugged packaging.

Unless your industrial application is constrained by overriding size, weight, or environmental considerations, it's unlikely that you'll be able to justify paying the high prices for these parts, which typically range from $1000 to $2000. However, as industrial applications for 1553B emerge, you can expect some of these manufacturers to introduce industrial-grade parts. ILC Data Device Corp's UK Div, for example, has already joined Marconi Electronic Devices in supporting ERA Technology's promotion of 1553B as the field bus for manufacturing-automation networks. **EDN**

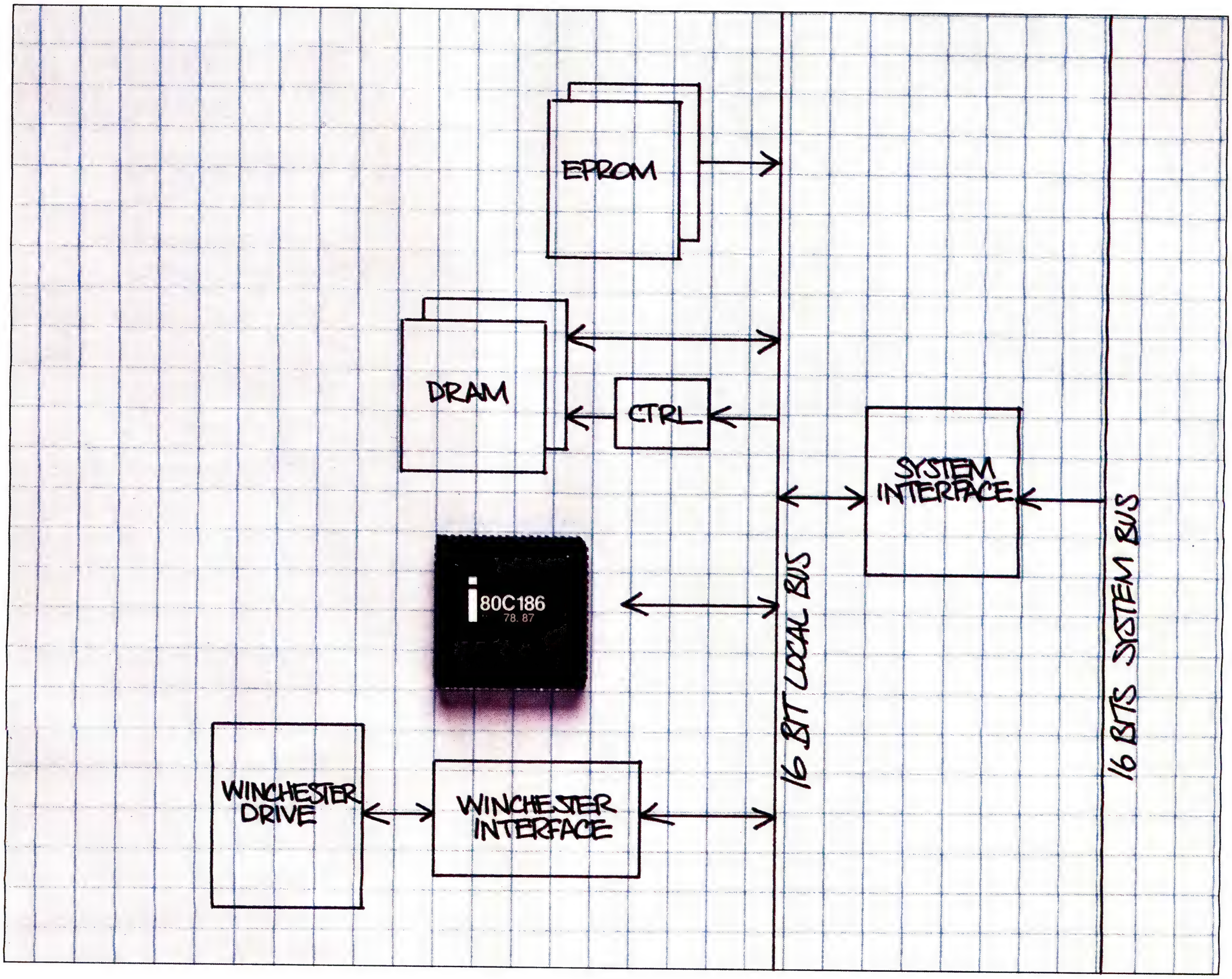
References

1. *MIL-STD-1553B, 21 September 1978, Aircraft internal time division command/response multiplex data bus*, Department of Defense, Washington, DC.
2. *MIL-HDBK-1553, 9 November 1984, Multiplex Applications Handbook*, Department of Defense, Washington, DC.
3. *Industrial Field Bus Based on MIL-STD-1553B Development and Trials*, ERA Technology, Leatherhead, UK.
4. Titus, Jon, "MIL-STD-1553 bus finds use in diverse military systems," *EDN*, April 11, 1985, pg 60.

Article Interest Quotient
(Circle One)
High 509 Medium 510 Low 511

INTEL MADE ITS
HIGH PERFORMANCE
CMOS CONTROLLER
SO COMPLEX,

ALL YOU HAVE TO DO IS PLUG IT IN.



Our highly integrated 16-bit 80C186 CMOS controller is pin-for-pin compatible with the industry standard 80186 chip. But it provides 1.5 times the throughput. Giving you the best of both worlds—a very powerful solution that is very simple to design in.

Which means you can forget about the time and hassle of costly re-designs. Simply plug in the 80C186 whenever you have an application that requires fast management of large amounts of memory.

But that's only the beginning. You'll get those higher clock speeds with 1/5th the power requirement. Because the 80C186 is fabricated in Intel's high-performance CHMOS technology. And we've optimized system power even more with our new Power Save Mode. When operating in this mode, the CPU remains active while allowing slower background processing, reducing power requirements by more than half.

We've also squeezed a whole lot of functionality onto the chip. The 80C186 has 2 DMA channels with 4 operational modes, allowing all combinations of I/O and Memory and a 1 Megabyte Maximum Transfer Block. And the DRAM Refresh Control Unit gives you the flexibility of programming from 18 to 512 clocks.

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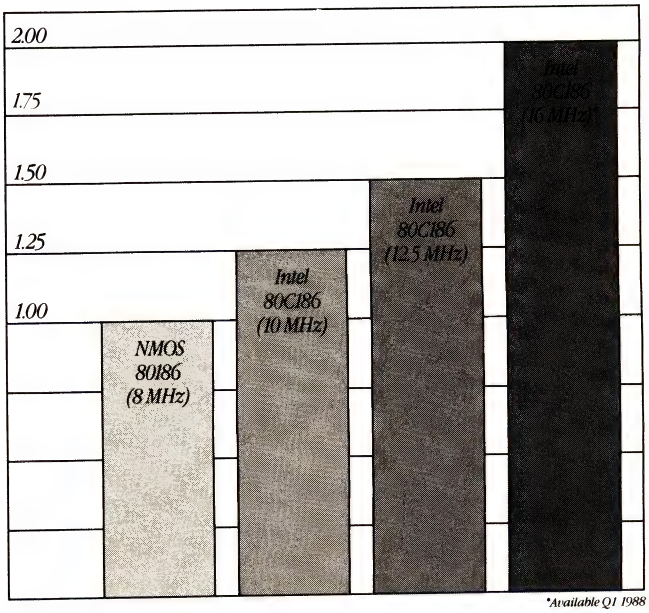
The 80C186 helps you get to market faster too. Because we offer complete development support. Including a compatible line of software development languages, such as C, ASM, PL/M, FORTRAN, and Pascal.



*Available Q1 1988

Intel's 80C186 versus 1st generation high integration microprocessors.

And Intel's new ICE™ 186 In-Circuit Emulator for 12.5 MHz 80C186 development. Full documentation and Intel's Field Applications Engineers help shorten your design time even further.

For more information on the 80C186, call Intel at (800) 548-4725 and ask for Literature Department W386.

And we'll show you how simple innovation can be.

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Higher density, lower profile SIMM sockets from AMP. We've covered all the angles.

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Get the styles you need with AMP SIMM Sockets, and get the well-thought-out design and reliability you can always expect from AMP.

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All are designed for uncomplicated, straight-in module insertion, with no clearance requirements from adjacent components. Housings provide polarization, with a separate mechanical latch for module retention.

All utilize our exclusive high-normal-force "floating" contact system, too—positive wipe gas-tight interface, with complete independence from housing materials for long-term integrity.

And all are designed for compatibility with industry-standard processing equipment—with high-temperature materials, close-tolerance soldertail positioning, closed-bottom housings, robotic pick-up details.

All the details, in fact, that make AMP worth remembering for SIMM Sockets.

Call (717) 780-4400 and ask for the SIMM Socket Desk.
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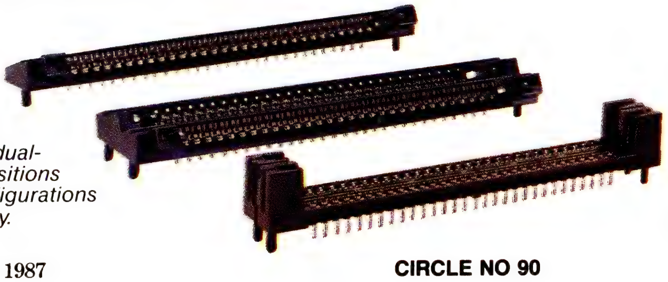
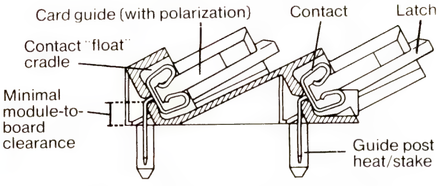
AMP Interconnecting ideas



Vertical single-row sockets in 12-42 positions, slanted single-row sockets in 22-42 positions, and vertical and slanted dual-row sockets in 30 positions available. Other configurations to be available shortly.


Card guide (with polarization)
Contact
Latch
Contact "float" cradle
Minimal module-to-board clearance
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High-pressure tin-to-tin contacts provide reliable performance. Contacts with select gold plating also available.

CIRCLE NO 90

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Somewhere in the depths of even the simplest embedded microprocessor system design is the risk of a timing-dependent bug. Or two. And not even a million years of conventional testing can catch them all.

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Suppose, though, that there was a software development system that would *free you from time-dependent errors by design.*

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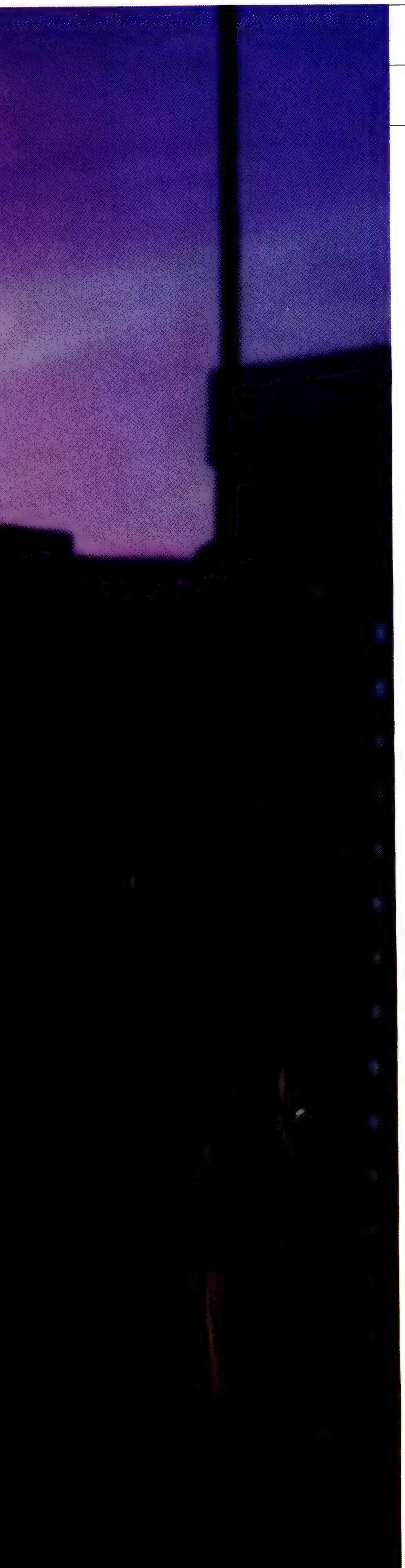
CIRCLE NO 91

Your window of opportunity

C&C
Computers and Communications



V70—the 32-bit microprocessor with the right technology at the right time

The V70 supermicro is your window of opportunity into the 32-bit world. By moving up now, you can stake your claim to emerging markets. And get the benefits of high integration, exceptional speed and sophisticated on-chip functions. All in CMOS.

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The V70 delivers 6.6 MIPS (max) at a 20MHz clock rate. The six-stage pipelined CPU executes up to four instructions concurrently.

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The on-chip demand-paged Memory Management Unit supports 4 gigabytes of virtual and physical memory spaces. And gives you 4 levels of memory protection.

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The V70 executes basic floating point operations (IEEE 754) without co-processor.

EFFICIENT PROGRAMMING

The V70 features 32 general-purpose registers (each 32 bits wide) and a powerful instruction set optimized for high-level languages and operating systems such as UNIX and MS-DOS.
V70 instructions are fully compatible with the V60. A high-speed emulation mode gives you compatibility with V20/V30 software.

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The V70 helps you design fault-tolerant systems with its unique on-chip Functional Redundancy Monitor. Use two V70's, one master and one checker. During each bus cycle, the checker monitors the master and issues mismatch warnings.

ON-CHIP DEBUGGING

The V70 offers three types of debug functions on-chip. V70 users get full support from NEC, including a broad line of CMOS peripherals, development tools, and two operating systems—UNIX system V and our realtime OS.

If you've been looking into the 32-bit world, it's time to step through the window of opportunity. With the V70 from NEC. Find out about it today.

For further information, please contact:

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The OMNIMODULE™ Concept
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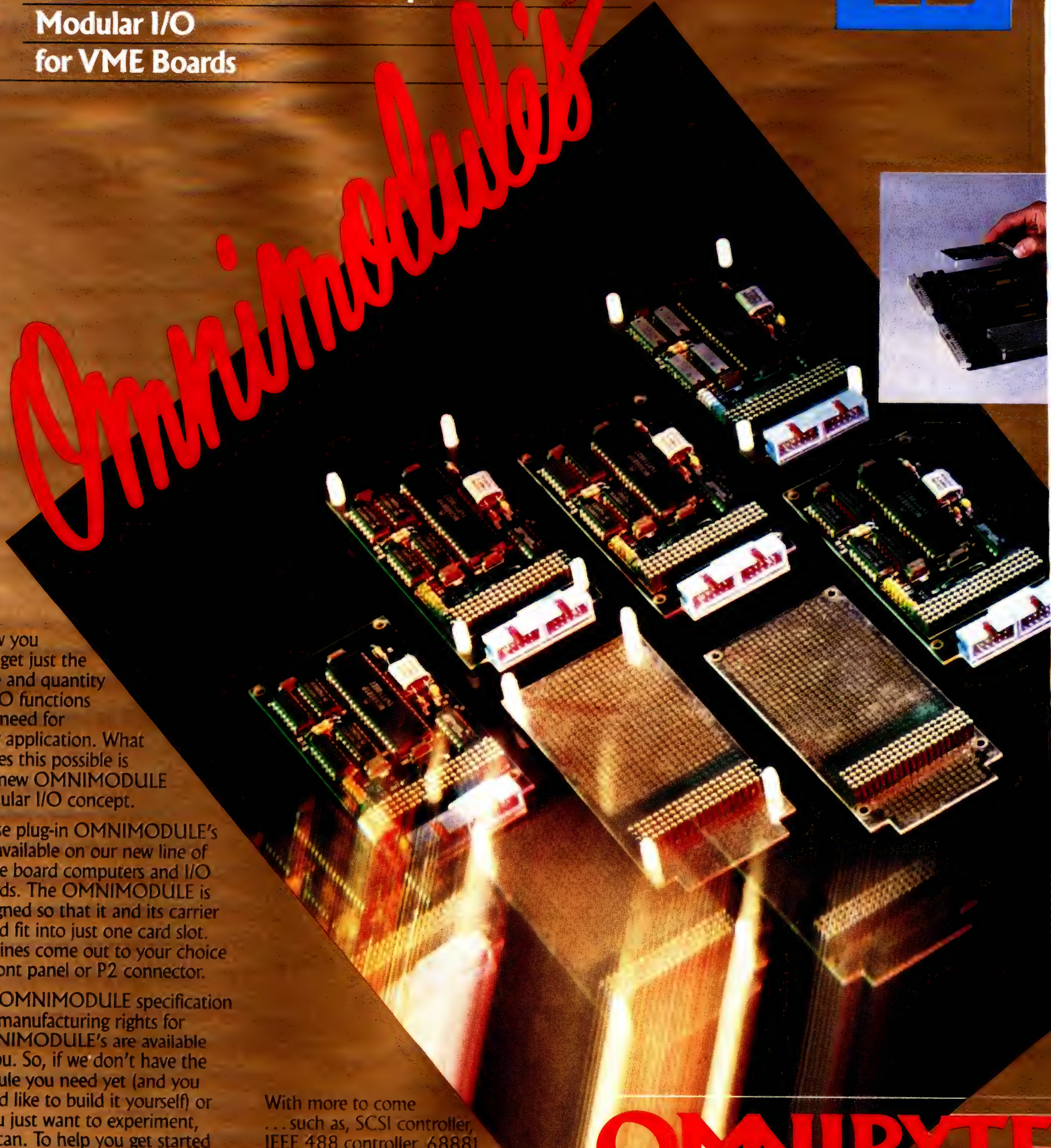
for VME Boards



Now you can get just the type and quantity of I/O functions you need for your application. What makes this possible is our new OMNIMODULE modular I/O concept.

These plug-in OMNIMODULE's are available on our new line of single board computers and I/O boards. The OMNIMODULE is designed so that it and its carrier board fit into just one card slot. I/O lines come out to your choice of front panel or P2 connector.

The OMNIMODULE specification and manufacturing rights for OMNIMODULE's are available to you. So, if we don't have the module you need yet (and you would like to build it yourself) or if you just want to experiment, you can. To help you get started we offer a kluge prototyping OMNIMODULE. In addition to the kluge OMNIMODULE we also offer the following OMNIMODULE's today:

- (2) RS232C asynchronous serial ports.
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- (2) RS422 asynchronous serial ports.
- (20) lines of parallel I/O.

With more to come . . . such as, SCSI controller, IEEE 488 controller, 68881 math co-processor, (2) RS422 synch/asynch serial ports, etc.

For a free data sheet and to find out more about the OMNIMODULE I/O modules, or our new line of single board computers and I/O boards, contact our Marketing Manager, Peter Czuchra at 1-800-638-5022 or (312) 231-6880 in Illinois.

A copy of our Omnimodule specification is available for $10.00.

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CIRCLE NO 92

A Look At Today . . . A Vision Of Tomorrow.

Buscon/87: Technical sessions and products for computer-bus designers and users

EDN Staff

The Buscon/87 show, a combination of product exhibits and technical sessions, moves up the East Coast this year, from New York last fall to Massachusetts this fall. You'll be sure to find something of interest in the array of products and technical presentations at Buscon—even if you aren't currently involved with computers or computer-bus products. The show, which takes place at the Royal Plaza Hotel and Trade Center in Marlborough, MA, opens on October 5 and runs for four days.

Although the show's technical sessions will take place throughout the four days, exhibits of new computer products will be open only on October 6 and 7 between 11 AM and 6 PM. The show's organizer, Multidynamics/CMC (Cerritos, CA, phone (213) 402-8814), has a sellout group of about 130 exhibitors and expects an attendance of more than 3000 systems designers and integrators at the exhibits and technical sessions.

The Buscon technical sessions encompass technical papers, 1- and ½-day seminars, and short special events. If you haven't preregistered for the show, you can register at the hotel, which will serve as the show's headquarters. The hotel will house all the meeting rooms and exhibit areas.

The cost for the complete program of technical sessions and exhibits is $225. Technical papers and presentations from the sessions will be available as reprints (a set is included in the $225 fee). If you want to skip the technical sessions and exhibits, you can register for the seminars independently. Seminar prices start as low as $110.

Travel tips

If you're flying into the Boston area for the Buscon show, choose your arrival time carefully. Getting out of Boston's Logan Airport area involves traveling through a tunnel, which is usually clogged. Avoid arriving during the morning and afternoon/evening rush hours. Even weekend traffic at Logan can be a nightmare. Instead, you might consider flying into Worcester, MA. Worcester is closer to Marlborough, and the highways aren't as busy. Marlborough is located on Interstate 495, west of Boston and east of Worcester.

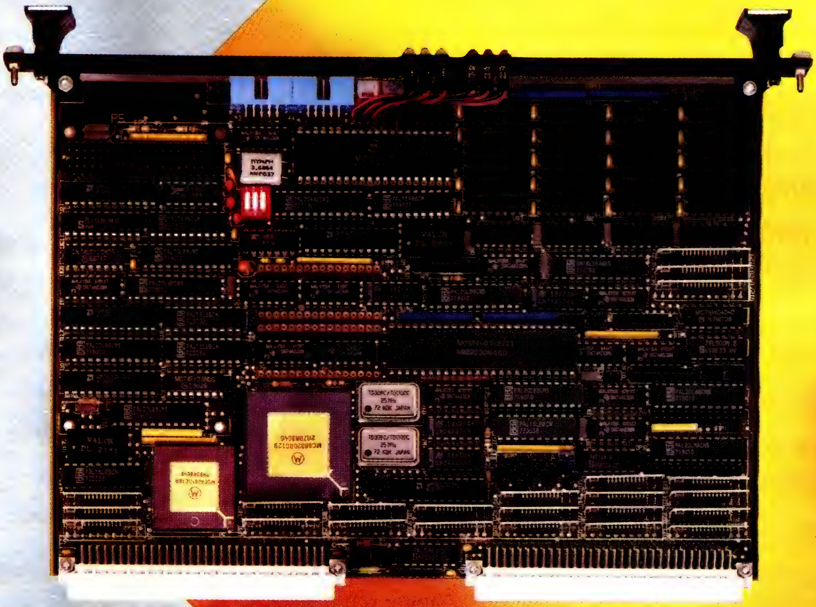
When you get to Buscon, you'll be able to choose from a full schedule of computer-bus seminars and technical meetings. Although the product displays won't open until 11:00 AM on Tuesday, October 6, you'll have a choice of four seminars to keep you busy on Monday. A ½-day seminar, "VME Bus Overview," will provide a technical review of the VME Bus as well as details of the four subbuses within the VME Bus's framework. The instructor, Wayne Fischer of Force Computers (Los Gatos, CA), will also describe packaging considerations and bus-performance issues. If the VME Bus tickles your fancy, you might also attend an afternoon seminar by Fred Rehhausser of Motorola Inc (Tempe, AZ): "VSB: A VME Subsystem

BUSCON/87 TECHNICAL SESSIONS AND SEMINARS

MONDAY, OCT 5 SEMINARS	TUESDAY, OCT 6 9:00 AM TO 11:00 AM	WEDNESDAY, OCT 7 9:00 AM TO 11:00 AM	THURSDAY, OCT 8 SEMINARS
A TECHNICAL LOOK AT BUS STRUCTURES AND APPLICATIONS—9:00 AM TO 5:00 PM	**SESSION 1**—BACKPLANE SYSTEMS	**SESSION 7**—ANALOG I/O APPLICATIONS	DESIGNING WITH THE MESSAGE-PASSING COPROCESSOR—9:00 AM TO 6:00 PM
VME BUS OVERVIEW—9:00 AM TO 12:30 PM	**SESSION 2**—REAL-TIME OPERATING SYSTEMS	**SESSION 8**—REAL-TIME KERNELS	FUTUREBUS WORKSHOP—9:00 AM TO 5:00 PM
VSB: A VME SUBSYSTEM BUS—1:30 PM TO 5:00 PM	**SESSION 3**—INTERFACES	**SESSION 9**—SYSTEM ARCHITECTURE	IBM's MICROCHANNEL ARCHITECTURE: EXPLORING EMERGING PC 32-BIT BUS STRUCTURES—9:00 AM TO 5:00 PM
THE NUBUS AND A MACINTOSH II-NUBUS WORKSHOP—9:00 AM TO 5:30 PM	**2:00 PM TO 4:00 PM**	**2:00 PM TO 4:00 PM**	
	SESSION 4—HIGH-SPEED PROCESSING	**SESSION 10**—COMMUNICATIONS I/O APPLICATIONS	
	SESSION 5—HIGH-PERFORMANCE SCSI	**SESSION 11**—LINKING UNIX TO A REAL-TIME ENVIRONMENT	
	SESSION 6—TOOLS, TIPS, AND TECHNIQUES	**SESSION 12**—MULTIPROCESSING	

Our New 68020 VME SBC Gives You a Port for any Storm

OB68K/VSBC20™ with OMNIMODULES™



You work hard to find a 68020 single board computer that meets your I/O requirements. If you can't find one, your design and budget could be in trouble.

Our OB68K/VSBC20 with its OMNIMODULE modular I/O, adjusts to meet your I/O needs. It can give you just the right type for your specific application. It can even accommodate last minute changes in your I/O requirements. The OB68K/VSBC20's OMNIMODULE socket allows you to add more ports, through plug in I/O modules. You can add 2 more serial ports or 20 more lines of parallel I/O. Specialized interfaces such as GPIB or SCSI can also be added. Our prototyping module even allows you to implement custom I/O. And with an OMNIMODULE on board, the OB68K/VSBC20 still uses only one slot.

In addition to its modular I/O, the OB68K/VSBC20 comes standard with 2 RS232C async serial ports and a 16-bit parallel port. The OMNIMODULE and on board serial I/O is brought out to your choice of front panel or P2 connector. On board parallel I/O is brought out to the P2 connector only.

The OB68K/VSBC20 is fast and flexible with a 12.5 MHz 68020 standard (16.7 and 25 MHz optional). Its 1MB of parity-protected dual-access, low cost dynamic RAM operates at 0-wait-states even at 16.7 MHz!

Additional features include:

- 68881 or 68882 Math Co-Processor (optional).
- (2) 32-pin ROM sockets (up to 256KB).
- Supports unaligned transfers (UAT).
- (1) 16-bit and (1) 24-bit timer/counter.
- (7) prioritized interrupts.
- IEEE 1014 (Rev. C.I) compatible.
- 4 level VME BUS arbiter (optional).
- 2 year limited warranty.

Today your choice of OMNIMODULE's include:

- Kluge prototyping module.
- (2) async RS232C serial ports.
- (2) syn/async RS232C serial ports.
- (2) async RS422 serial ports.
- (20) lines of parallel I/O.
- SCSI controller.
- GPIB interface.
- And more to come!

For a free data sheet or to learn more about our OMNIMODULE modular I/O, contact our Marketing Manager, Peter Czuchra at 1-800-638-5022 or (312) 231-6880 in Illinois. Send $10.00 for a detailed technical manual or a copy of our OMNIMODULE specification.

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A Look At Today . . . A Vision Of Tomorrow.

CIRCLE NO 131

Bus" will furnish information about using VME Bus computers in multiprocessor systems.

Two day-long seminars are also available: "A Technical Look at Bus Structures and Applications" and "The NuBus." The first seminar will offer a detailed look at bus structures in general and information about current popular buses and those that are under development for future applications. The seminar will also include comparisons of buses and design and marketing information. James Davis of Summitt Computer Systems (Los Gatos, CA) will lead the seminar.

The NuBus seminar, directed by George White of Corollary Inc, will give attendees a detailed technical description of the NuBus along with performance and cost data. The NuBus is becoming popular because Apple Computer adopted it for use in the Macintosh II computer system. For more information on applications of the NuBus, you can attend the afternoon part of the NuBus seminar, in which members of Apple Computer's technical staff will describe the Macintosh II computer and how it takes advantage of the NuBus architecture. You'll also learn how to convert existing designs so they can operate to the NuBus's specifications.

Three day-long seminars are scheduled for the last day of the show. You can attend a product and marketing session, a general bus overview, or a roundup of technical computer-related topics. For example, in the Multibus II seminar, "Designing with the Message-Passing Coprocessor (MPC)," Intel marketing engineer Shaun Maki will describe how to apply Intel's MPC chip to Multibus II applications.

If you're not involved with Multibus II products, you might consider learning about Futurebus. The US Futurebus Manufacturers' and Users' Group will sponsor the "Futurebus Workshop," which will give an overview of the bus. You'll have an opportunity to learn more about general Futurebus requirements and specifications from the nine people in the program.

The final seminar, "IBM's Microchannel Architecture: Exploring Emerging PC 32-bit Bus Structures" would have been better split into two independent sessions. As it is, during the first part of the program representatives from IBM will describe the Microchannel bus—the bus structure in the company's new line of PS/2 computers. Later in the program, several industry representatives will talk about disparate topics such as a low-cost Ethernet controller and the STE bus.

The Buscon schedule also includes a variety of special-event meetings, which will occur throughout the conference. Meetings include the Multibus Manufacturers' Group reception, discussion groups, a marketing executives' seminar, and meetings of committees to discuss new bus architectures and standards.

The main technical program at Buscon will take place on October 6 and 7—the same days the exhibits will be open. Three concurrent sessions will be held each morning and each afternoon. The technical sessions will cover a broad spectrum of topics, but hardware-related topics will dominate. The sessions will revolve around three major areas: system and bus architecture, real-time software, and I/O techniques.

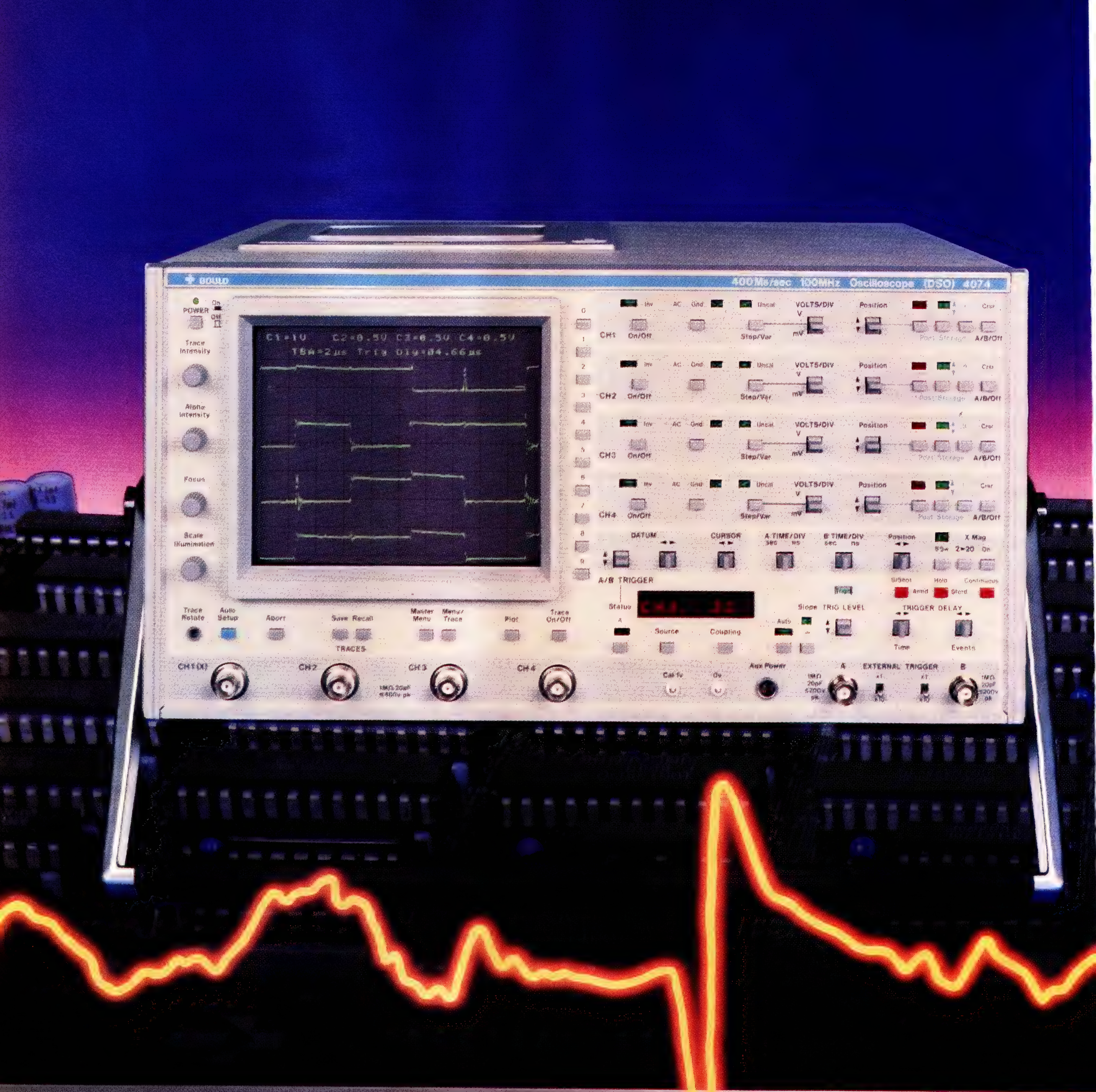
Four of the technical sessions (**1**, **3**, **9**, and **12**) will deal with general bus architecture, system architecture, and multiprocessing applications. For example, in "Backplane Systems" (**Session 1**), participants will discuss backplane and bus issues such as metastability and timing considerations. In the "Multiprocessing" meeting (**Session 12**), the speakers will describe how multiprocessing takes place on several different buses.

Three other sessions (**5**, **7**, and **10**) will cover topics that appeal to people who connect computers to external devices. In the "High-Performance SCSI" session (**Session 5**), the five speakers will talk about integrating high-performance SCSI; multiprocessing applications; cache storage; and SCSI protocol chips. In **Session 7**, five other speakers will describe how you get analog signals into computers used for data-acquisition and digital-signal-processing applications. Also, because communications with other computers and I/O devices require high-speed communications, **Session 10** will address serial buses, networks, and other communications schemes.

If software holds more appeal for you than hardware does, you'll probably want to attend at least one of the three sessions (**2**, **8**, and **11**) that cover real-time software. For example, in **Sessions 2** and **8** you'll receive an overview of real-time kernels and operating systems. Likewise, in **Session 11**, you'll learn more about using Unix and Unix-like operating systems in real-time environments.

Sessions 4 and **6** don't fit into one of the above categories, but both offer helpful information. In the "High-Speed Processing" meeting (**Session 4**), you'll have a chance to hear speakers talk about applications that depend on fast processing. Examples include image processing, document processing, and digital signal processing. You may also find something worth listening to in the potpourri of topics in **Session 6**, which is entitled "Tools, Tips, and Techniques." Topics on the schedule include emulative testing of μP-based systems, developing real-time software without writing code, low-cost I/O development, and desktop CAE solutions. **EDN**

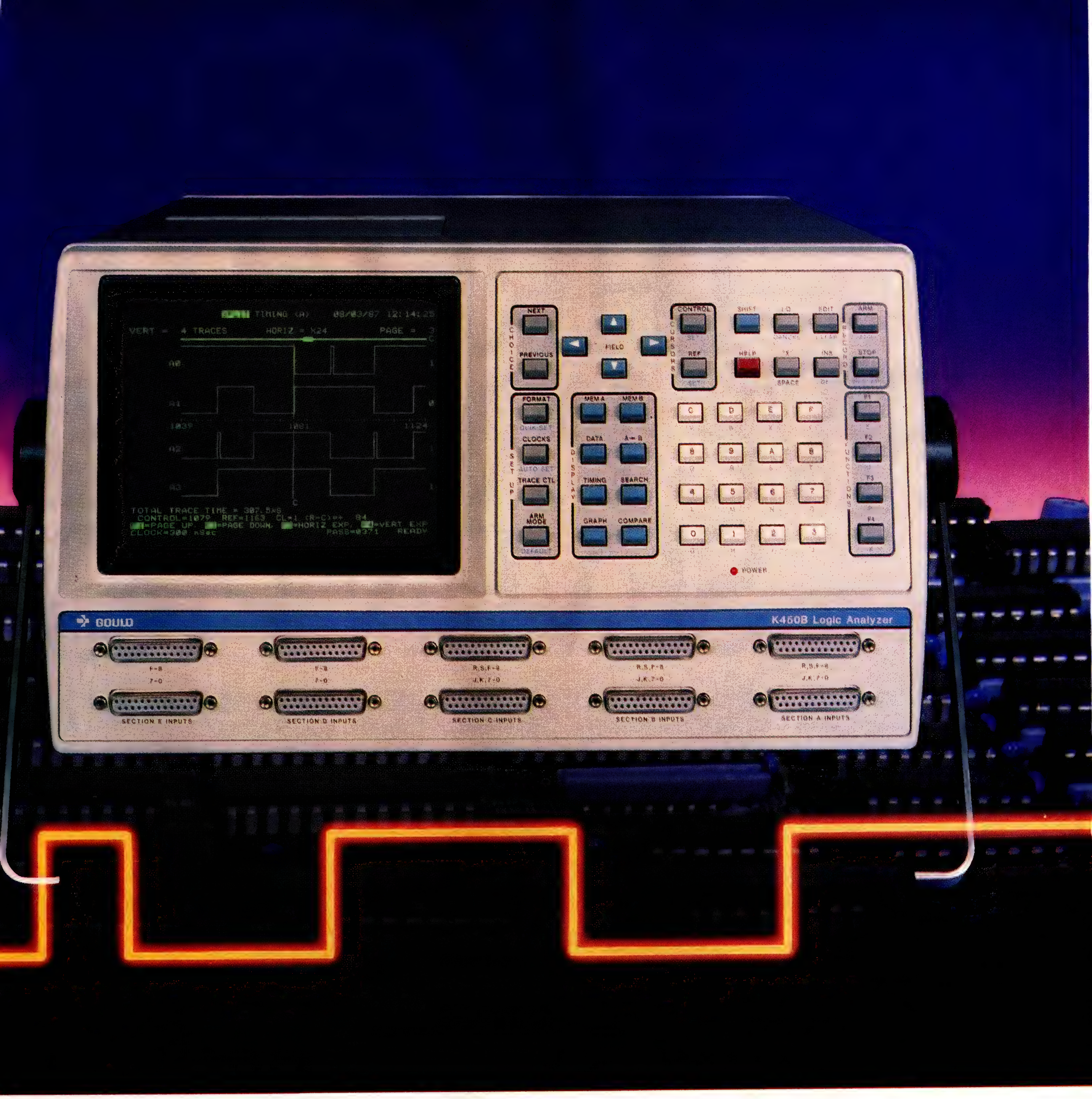
Article Interest Quotient
(Circle One)
High 512 Medium 513 Low 514



Team Performance

Gould 4070 Digital Oscilloscope
400 MS/s (sampling rate)

Gould K450B Logic Analyzer
80Ch. @ 100 MHz/40Ch @ 200MHz



Start solving your design problems today!
Gould offers two powerful tools to help the digital design engineer track down and eliminate intermittent failures. Used separately or teamed together with sophisticated triggering, they provide the power to resolve design problems.

The K450B Logic Analyzer, with 80 channels at 100MHz or 40 channels at 200MHz, gives you an overview of the whole system so that individual glitches or timing errors can be located.

Using the 4070 Digital Storage Oscilloscope, with 2 or 4 channels at 400 Megasamples per second, you can capture the analog details of the waveform and find noise transients or race conditions which can be the source of the failure.

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4070 DSO	K450B LA
2 or 4 channels @ 400MS/s (400 Megasamples/sec.)	80 channels all @ 100MHz/ 40 channels @ 200MHz
2.5ns resolution on transient signals	5ns glitch capture on all channels
Auto Setup™	Auto Setup™
Trigger delay by time/events	16 levels of Trace Control™
Built-in 4 color screen plotter	Built-in disk drive

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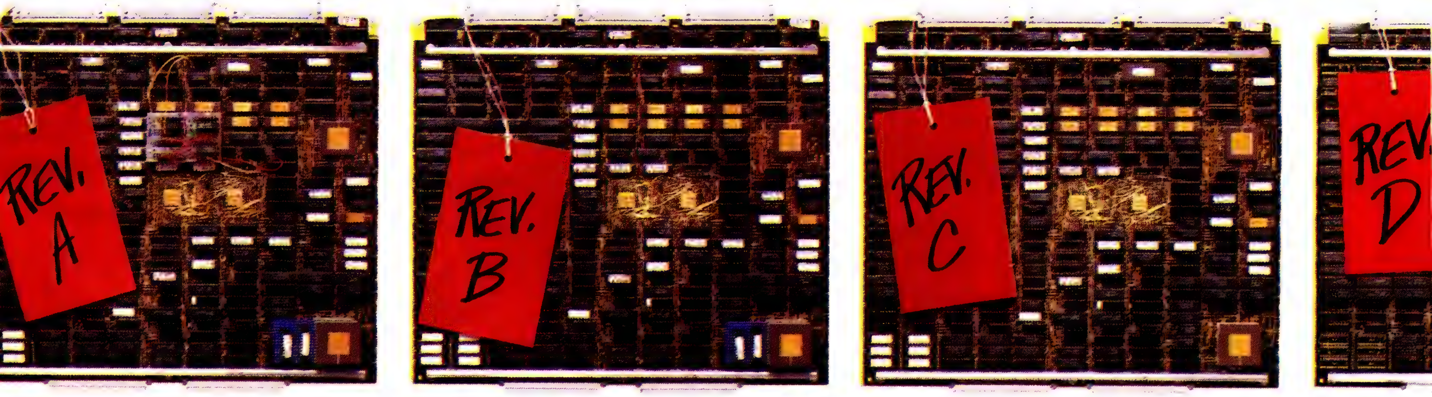
CIRCLE NO 93

ONE PROTOTYP
THREE PRO
FIVE PROTOTYP
SEVEN PRO



Teradyne's new CAE tools help you get to market faster

Designing VLSI circuit boards that work the first time isn't child's play. You can't do it without fast, accurate feedback on design and test quality.

Now count on Teradyne to help. With our new family of CAE products, you'll uncover flaws before they're cast in hardware. So you'll be able to jump from initial design directly to final prototype. And from design to manufacturing test.

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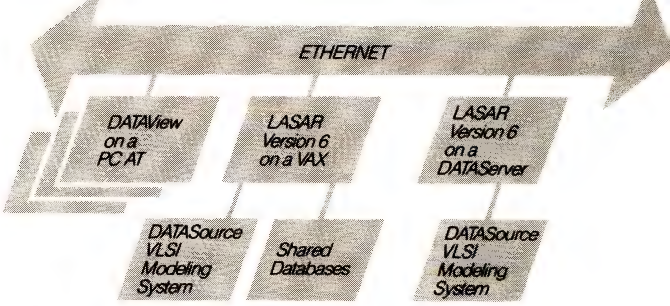
The process starts with DATAView our new design entry system. Running it on a standard AT-class PC, you can control the whole design process right at your desk. From schematic entry and waveform analysis on the PC to simulation and fault simulation on more powerful networked computers. All with the same mouse-and-menus, multiple-window interface.

You move from schematic capture to simulation effortlessly. DATAView's links with our LASAR Version 6 simulation system save hours of model compilation time. Incremental compiling lets you revise a design and resimulate in minutes.

Make your design work together before it comes together.

LASAR Version 6 is the only sure way to avoid multiple trips to artwork as well as costly rework steps in manufacturing. Because its simulation accuracy is unmatched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Shared Databases
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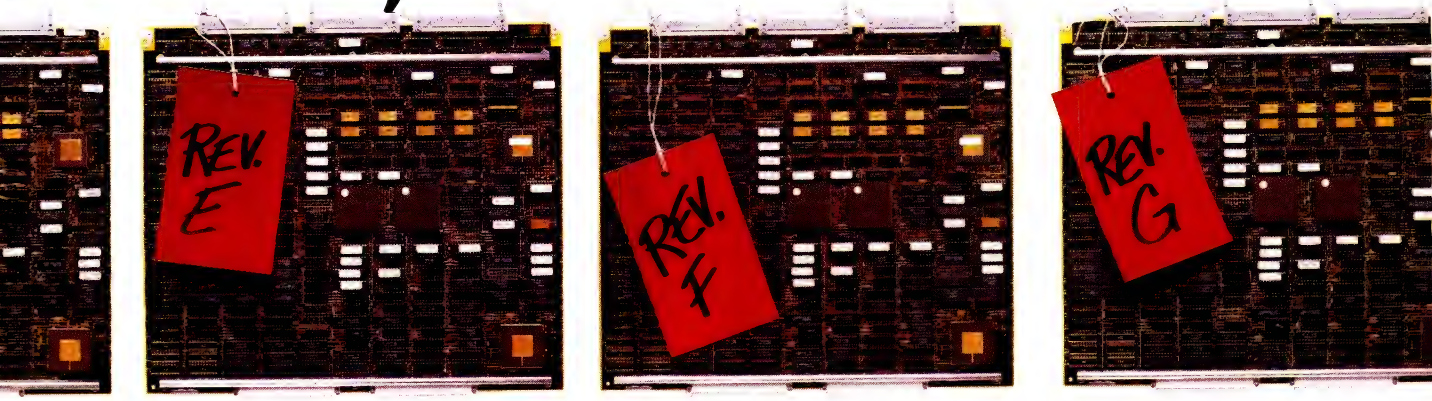

ving you a working prototype the first time.

for analyzing PC board designs prior to prototyping. For instance, LASAR takes full device timing specifications into account for true worst-case timing analysis. And it eliminates shared timing ambiguity in reconverging signals. Both of which mean LASAR finds real design errors reliably.

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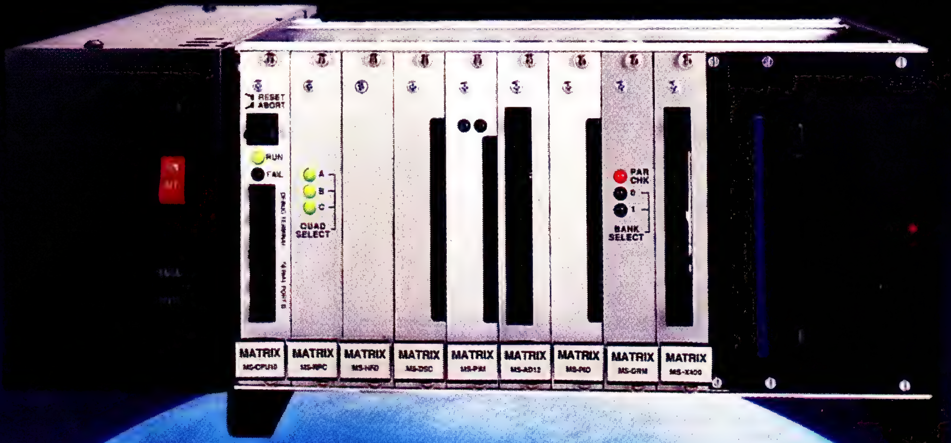

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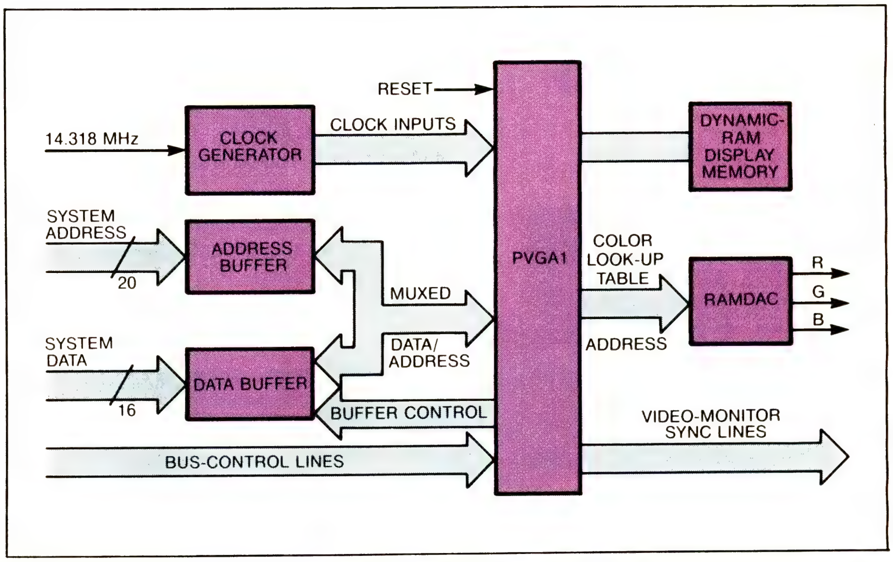
CIRCLE NO 94

IC supports PS/2 graphics modes and 800×600-pixel, 16-color resolution

The PVGA1 is a single-chip graphics controller that the manufacturer claims provides both hardware and software compatibility with IBM's Video Graphics Array (VGA), which is the standard graphics interface for the Personal System/2. The company also offers two VGA-compatible boards based on the chip.

Because the chip is compatible with the VGA at the register level, you can program the graphics hardware directly instead of programming only through the software-interface portion of the VGA BIOS (basic input/output system). This hardware compatibility confers a greater degree of confidence that a PVGA1-based board will be VGA compatible: In the past, application programs for the PC have bypassed the BIOS and accessed the graphics hardware directly to gain a speed advantage.



You can implement a VGA-compatible graphics board *with as few as 21 chips; in contrast, IBM's VGA add-in board for the PS/2 uses 32 chips.*

Besides supporting the VGA functions, the chip also supports the graphics standards developed for MS-DOS systems: the EGA (enhanced graphics adapter), MDA (monochrome display adapter), CGA (color graphics adapter), and Hercules and AT&T Model 6300 graphics boards. Note, however, that the chip supports the EGA standard only to the BIOS level, not to the register level.

Several companies have expressed concern about the ability of any manufacturer other than IBM to develop graphics controllers that are fully compatible with the VGA, because IBM has not documented all of the VGA board's graphics modes. The PVGA1's manufacturer claims that the undocumented VGA modes are used only for production

A RAMDAC for your graphics board

If you use the PVGA1 or a similar graphics-controller IC to design a graphics board for the IBM PS/2, you'll need a RAMDAC, a high-speed D/A converter that incorporates a color look-up table in its RAM. Although IBM uses the Inmos G171 RAMDAC on its PS/2 graphics-controller boards, you have an alternative: You can use the Bt471 or Bt478 RAMDAC from Brooktree. Each comes in a 44-pin plastic leaded chip carrier. This package is larger than the G171's 28-pin DIP, but the larger size allows for added features.

The Bt471 and Bt478 support as many as eight bit-planes plus four overlay planes, so they can display 256 simultaneous colors and 15 overlay colors. The total palette size is 256k colors; the Bt478 also offers 16M colors. Both chips operate at 40 or 80 MHz. The manufacturer claims that the Bt478 RAMDAC is suitable for use in a board compatible with IBM's 8514/A (an optional higher-resolution graphics board for the PS/2). The Bt478's 80-MHz frequency eliminates the flicker that some viewers have complained about in the 8514/A. The Bt471 and Bt478 each cost under $20 in OEM quantity.

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CIRCLE NO 14

testing of the board's custom ICs and do not affect any graphics programming.

The PVGA1 implements a proprietary mode that offers 16 colors and a resolution of 800×600 pixels (which is, not coincidentally, the maximum resolution of an NEC Multisync monitor). Its monochrome mode provides 1280×1024-pixel resolution. The vendor claims that boards based on the PVGA1 will offer better performance than that of the VGA; the company's proprietary bus interface for the PVGA1 allows data transfers of 8 bits over the PC bus and 16 bits over the PC/AT bus.

Another mode, Mode 13, specifies a resolution of 320×200 pixels and 256 colors. In your search for higher resolutions to render more realistic images, don't forget that although pixel resolution is the most important factor in 2-D images, when you perceive 3-D images your eye is most sensitive to color resolution. Mode 13 is important for displaying digitized photographs.

Samples of the PVGA1 are available now; production quantities will be available in October. The chip costs $60 (100) and comes in a 100-pin plastic pin-grid array, plastic leaded chip carrier (PLCC), or plastic flat pack. It comes with a VGA-compatible BIOS. The Paradise VGA graphics board, which offers the same resolution as that of the IBM VGA, costs under $400; the Paradise VGA-Plus offers 800×600-pixel, 16-color resolution and sells for $600.—***Margery S Conner***

Paradise Systems Inc, 217 E Grand Ave, South San Francisco, CA 94080. Phone (415) 588-6000.

Circle No 631

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MODEM MODULE SELECTION TABLE

FEATURE	CH17L60	CH1765	CH17L70	*CH1780
SPEED (bps)	1200, 300, 110	1200, 300, 110	1200, 300, 110	2400, 1200, 300, 110
FCC** REGISTERED	YES	YES	YES	YES
HOST INTERFACE	SERIAL TTL	SERIAL TTL	SERIAL TTL	SERIAL TTL
AUTOMATIC OPERATION	YES	YES	YES	YES
CALL PROGRESS DETECTION	YES	YES	MODEM ANSWER TONE	YES
COMMANDS	CMI	AT	CMI	AT
SYNCH/ ASYNCH OPERATION	BOTH	BOTH	ASYNCH	BOTH
SIZE (Sq inches)	9	16	9	9
POWER	+5V −12V .55W OPTION −5V .35W	+5V ±12V 3W	±5V .3W	+5V 1W

*Low profile
**DOC registrable

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CIRCLE NO 95

Expert system shortens ASIC development cycle by reviewing and improving designs

The Design Advisor is a menu-driven expert system that reviews proposed ASIC (application-specific integrated-circuit) designs and offers advice on how to improve them. Exploiting expertise derived from more than 1000 man-years of design experience and textbook knowledge, the system provides a computerized resource for managing and optimizing your design process by targeting potential trouble spots and actual design errors, and by suggesting possibilities for design optimization.

The system is an integral element of the manufacturer's ViSys standard-cell and gate-array design environment, and it uses a design database representation that's common to all the system tools in the ViSys environment. You input design data to the system via a net-list description of your circuit-logic schematic. You can generate a net list for completed portions of your design and apply the Design Advisor to either specific modules or to the entire design.

Combining a database of design knowledge with an underlying multiparadigm reasoning system allows the expert system to analyze and recommend action related to logic design, testability, timing analysis, cost effectiveness, and logic minimization. The knowledge base encompasses such parameters as chip timing, synchronicity, testability, performance, and I/O. The software can also consider factors affecting overall design quality and manufacturability.

Using a hierarchy of design attributes to structure its recommendations, the Design Advisor checks your design for compliance with fundamental design techniques, including general rules for maintaining synchronous circuitry and warnings to prevent hazardous timing practices. The system also generates suggestions for minimizing die size to reduce manufacturing costs. An advice contradiction-and-opposition feature lets you resolve contradictions through dialogue with the system. Thus, the software helps you think through an issue and make certain that you haven't overlooked any details.

According to the manufacturer, the Design Advisor can perform most hierarchical module analyses in seconds or minutes, and you can reuse all hierarchical analyses to speed your final full-chip analysis. A "what-if" analysis feature lets you automatically review the results of various design strategies to investigate design tradeoffs. Based on a truth-maintenance inference engine called Proteus, the expert system uses nonmonotonic reasoning to maintain consistent results in the face of new or conflicting input.

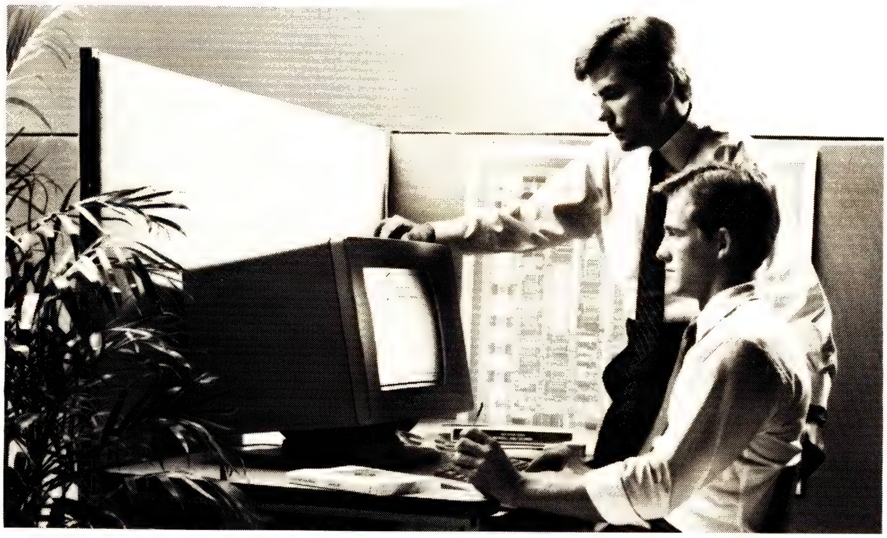
The system's multilevel menu-driven interface provides a format consistent with other ViSys tools. It features mouse-triggered commands, pop-up menus, a help facility, and an explanation utility to simplify your interaction with the system.

Currently, the manufacturer offers the Design Advisor as a dial-up design service with fees starting at $4000 per analysis. It plans to offer the system as a licensed option for its standard ViSys ASIC design system in early 1988. The software will run on a Mentor Graphics Idea engineering workstation under Lucid Common Lisp. The Design Advisor is the first commercial product using technology developed at the Microelectronics & Computer Technology Corp, a cooperative research consortium supported by 20 US-based electronics companies.

—J D Mosley

NCR Corp, Microelectronics Div,
8181 Byers Rd, Miamisburg, OH
45342. Phone (513) 445-3467.

Circle No 630



The Design Advisor, an AI expert system for ASIC designers, *takes advantage of more than 1000 man-years of relevant experience and knowledge to provide design advice.*

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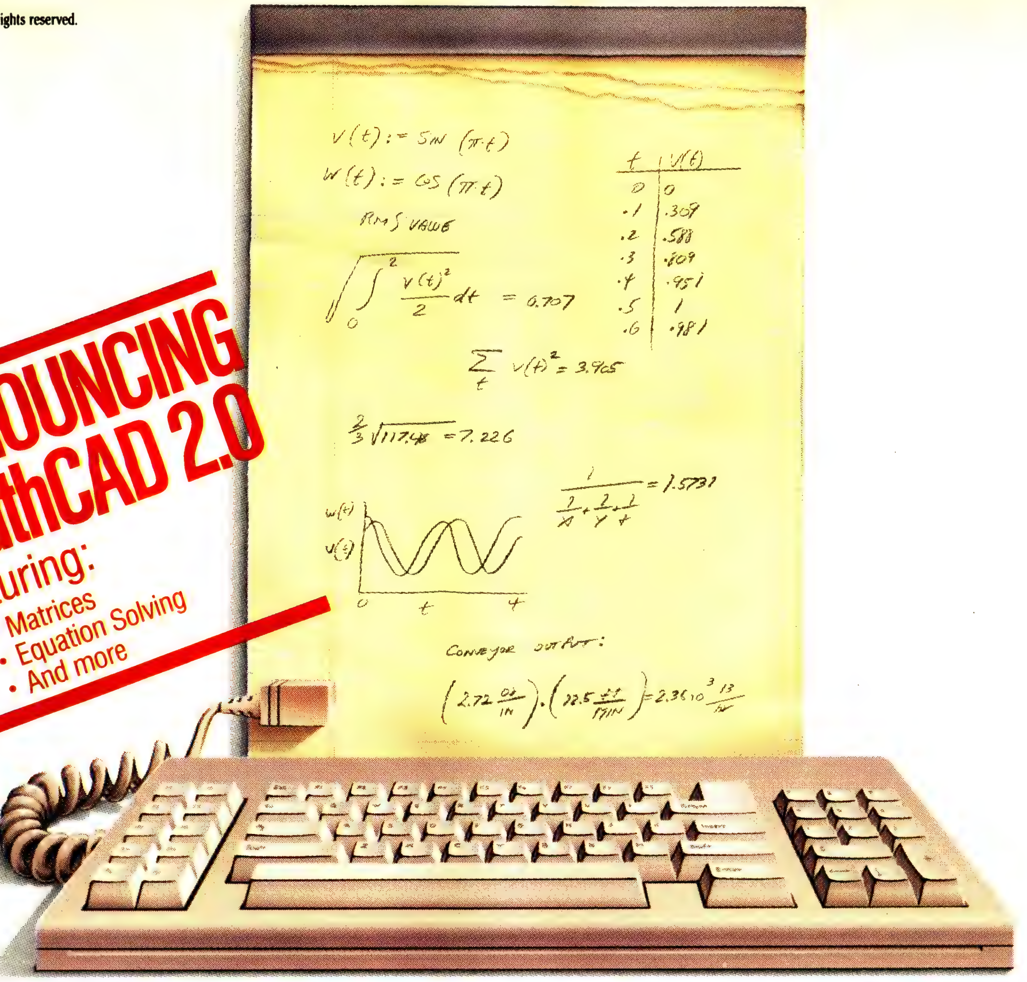

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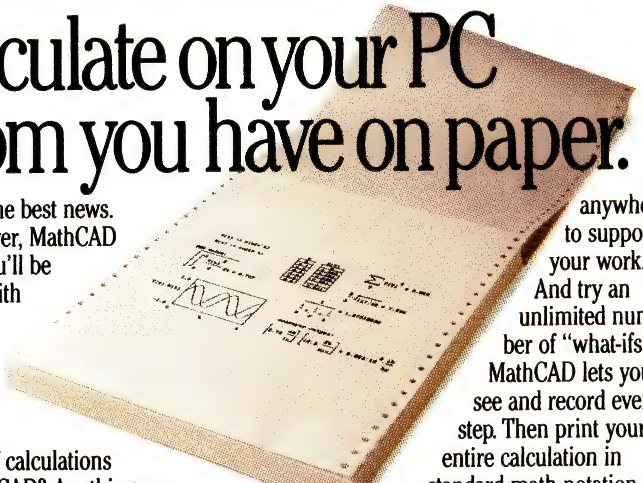

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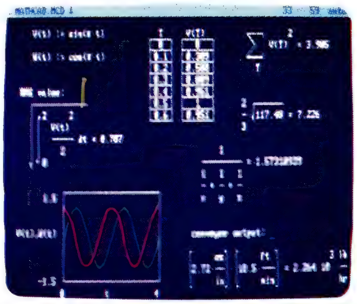

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CIRCLE NO 96

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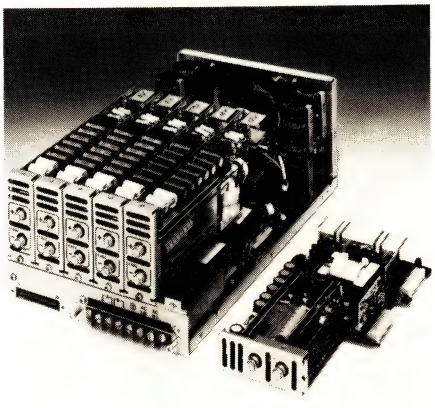
CIRCLE NO 97

Modular 1500W power supply offers user configurability



Six output modules provide 1500W total power for the Model 6D. The supply meets all international safety and emission standards.

The Model 6D Multimod power supply's totally modular construction gives you maximum design flexibility. The 1500W switching power supply accommodates six separate output modules, and any module can include multiple outputs. The entire supply measures 5×8×13.5 in. and offers 2.8W/in^3 power density.

The power supply consists of a mainframe that houses the plug-in modules. The mainframe accepts 115 or 230V ac inputs and converts the ac power to 300V dc. Each module is actually a dc/dc converter that receives power from the 300V dc bus. The supply employs 100-kHz MOSFET switching components and meets all international safety and emission standards such as VDE, CSA, and UL.

Because of the manufacturer's modular approach, designers can essentially choose from many off-the-shelf configurations. If your configuration uses modules with standard output voltages, the company can deliver your order in two days to four weeks. It can also provide fast delivery (eight to 16 weeks) of configurations that include modules with nonstandard voltages, because it only has to design and build the new modules.

You can now choose from single-output 300W modules ranging from 2 to 48V dc; the company also plans to offer multiple-output modules and modules that occupy more than one of the six plug-in spaces. A line of 750W triple-wide modules, for example, will be available soon.

All of the output modules use current-mode control techniques and are therefore inherently capable of current sharing. You can parallel the outputs of the modules to increase power ratings, and you can also parallel the modules to build fault tolerance into a system. With any module, you have the option of specifying internal isolation diodes, which allow you to isolate redundant parallel supplies in fault-tolerant applications.

The output modules have all the following pertinent specs in common. Outputs are adjustable to ±10% of nominal voltage, and line and load regulation are each 0.2% of the rated output. A current step-load change of 25% causes a maximum deviation of 3%, and the output will recover to within 1% of the nominal voltage within 400 μsec.

The modules also spec a thermal regulation of ±0.02%/°C, and ripple and noise are each 1% or 50 mV, whichever is greater. The modules include current limiting, overvoltage protection, reverse-voltage protection, and remote sensing. A supply equipped with six single-output modules costs $1500.

—Maury Wright

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CIRCLE NO 16

SCSI protocol IC performs 20M-byte/sec host transfers

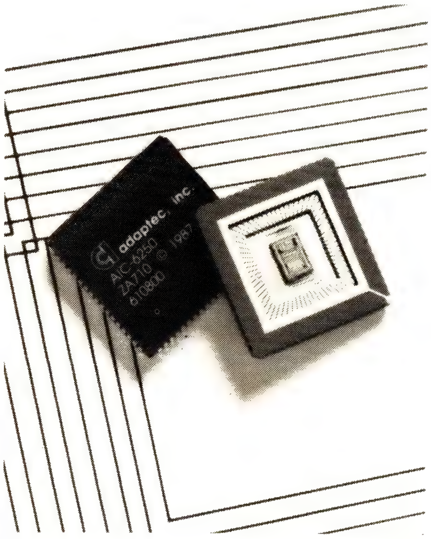
Joining a growing list of third-generation SCSI protocol ICs, the AIC-6250 supports asynchronous and synchronous data transfers across the SCSI bus. The CMOS IC includes a dual data-bus interface on the host side, and the host interface supports data transfers as fast as 20M bytes/sec. Single-ended bus transceivers are included on the chip; if you wish, you can directly interface external differential transceivers to the on-chip logic.

Like other third-generation SCSI chips, the AIC-6250 not only includes state machines for performing the SCSI protocol, but also automatically performs such functions as arbitration, selection, and reselection. The IC fits both target and initiator applications. As a target, the IC will automatically generate a response to selection or reselection.

The chip's architecture serves to offload the host's bus: In fact, the IC frees the host bus as much as 93% of the time during access to a SCSI peripheral. The chip uses a 16-bit bus to handle 8- or 16-bit data transfers in DMA or programmed I/O modes. A separate 8-bit data port allows the controlling µP to access the control registers at all times, even during DMA transfers.

On the SCSI-bus side, the IC performs 3M-byte/sec asynchronous transfers. You can program the chip for a synchronous offset of 8 bytes, and you can achieve 5M-byte/sec synchronous transfers. An 8-byte FIFO buffer links the SCSI bus and the host-bus interface. The chip can burst data into or out of the buffer at 20M bytes/sec.

You may choose to have the SCSI chip transfer data only into a local buffer: The AIC-6250's host interface works just as well with a local µP and memory as it does with a general-purpose computer host.



***Combining 5M-byte/sec synchronous SCSI transfers** with 20M-byte/sec host transfers, the AIC-6250 SCSI protocol chip targets high-performance applications.*

The chip also features automatic parity generation and checking, and it has two general-purpose I/O ports. In differential applications, the I/O ports control the differential transceivers. You can interface the SCSI chip to a µP without using glue logic, even if the µP uses a multiplexed data/address bus. The chip can interrupt the controlling µP on any of 14 conditions.

Samples of the AIC-6250 are available now, and production quantities will be available in the fourth quarter. The IC costs $20 (1000) and is packaged in a 68-pin plastic leaded chip carrier.

—Maury Wright

Adaptec Inc, 580 Cottonwood Dr, Milpitas, CA 95035. Phone (408) 432-8600.

Circle No 633

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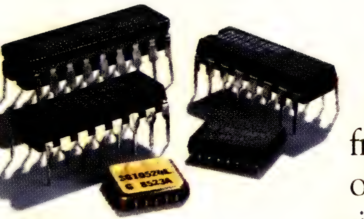

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SG1525AJ	SG3525AN
SG1526J	SG3526N
SG1527AJ	SG3527AN
SG1840AJ	SG3840AN
Current Mode	
SG1842J	SG3842N
SG1843J	SG3843N
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CIRCLE NO 98

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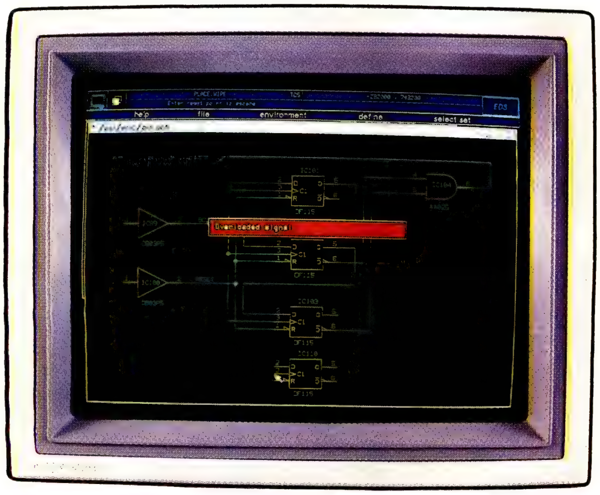

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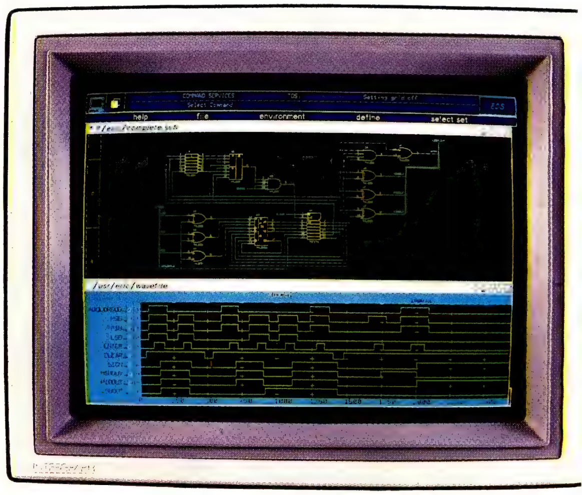

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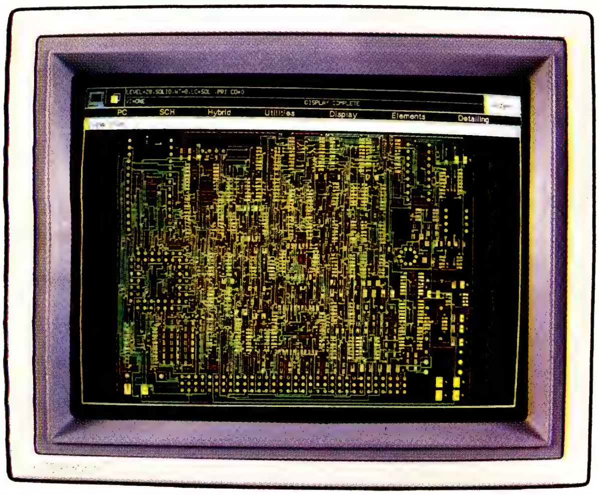

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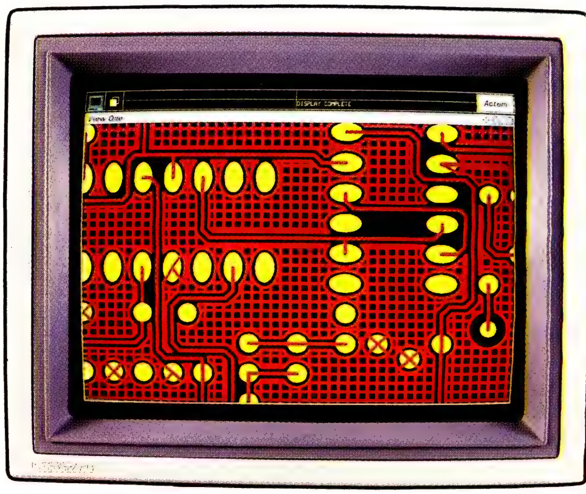

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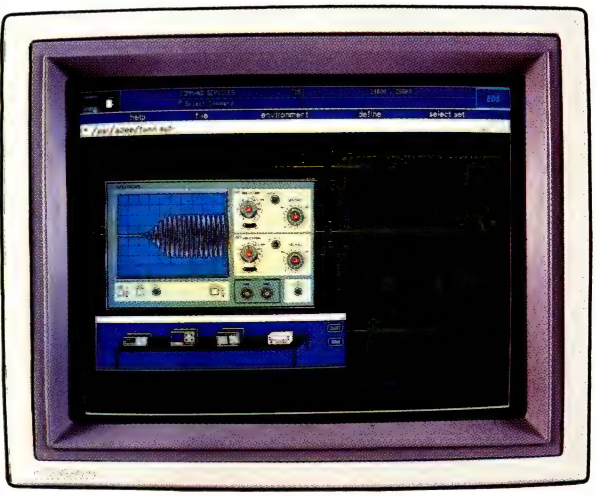
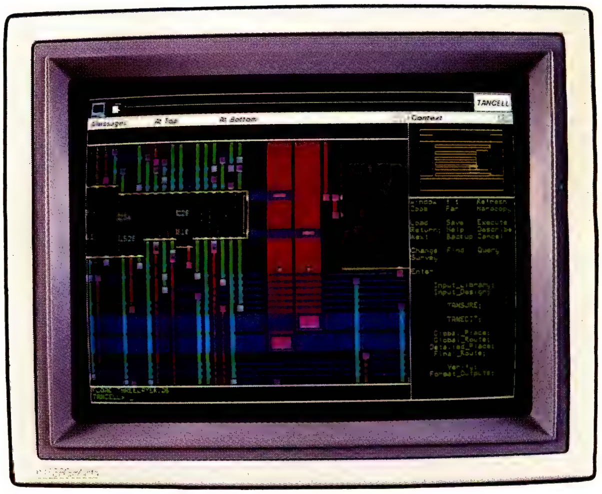
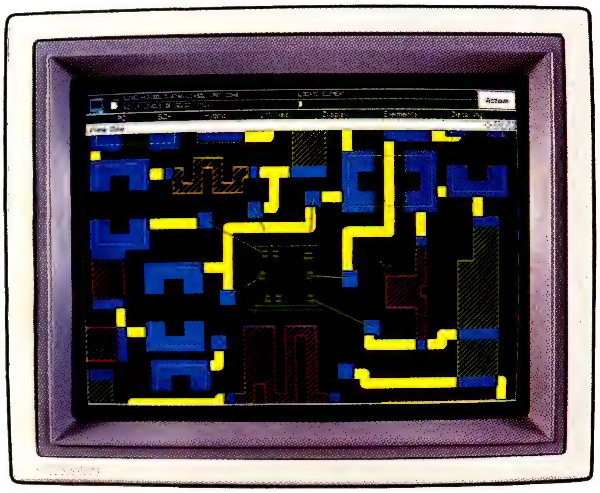


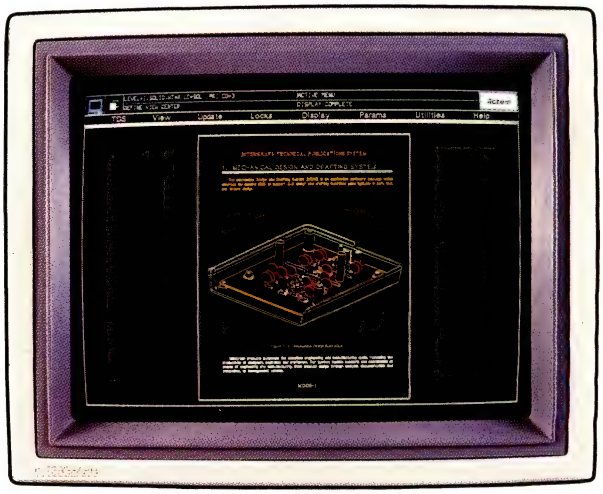
Easy-to-use virtual instruments provide a familiar interface for analog analysis using Intergraph's Cspice or ACS



Reduce ASIC die size and improve yield with Tangent Systems' timing-driven layout, automatic design for testability, and test pattern generation



A dedicated package for thick and thin film hybrid design features automatic resistor generation and automatic routing of chip and wire parts and SMDs



64-bit mechanical design packages and electronic publishing software round out a system for total product development

So the next time you think about integrating all your project tasks and speeding up development, do what many FORTUNE® 500 companies are doing. Think Intergraph.

For more information or a demonstration, call your nearest Intergraph representative. Call toll-free 1-800-826-3515 or (205) 772-2700. Call (31) 2503-66333 in Europe.

Think Intergraph for Superior Design Automation

INTERGRAPH

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CIRCLE NO 99

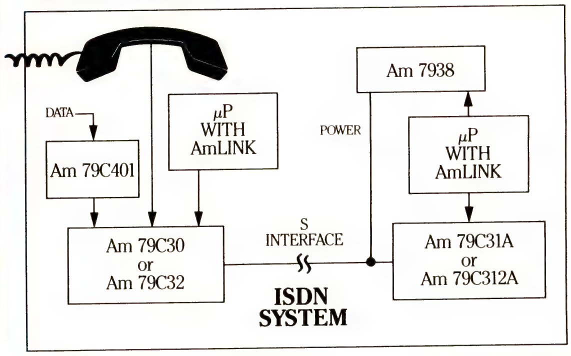
Starting with ISDN is one thing. Finishing is something else.

It's possible to put together your own ISDN chip set. Subscriber controller here, power supply there, line card device from somewhere else.

But why? Advanced Micro Devices can deliver the whole connection.

The ISDN chip set that's made for each other.

With AMD's five chip set, everything is included. All designed to work together. And to conform to the CCITT recommendations.



The set is so highly integrated, you won't need extra chips for things like dialing and ringing.

Each of AMD's chips was designed to take advantage of the most efficient technology for its function, including bipolar and CMOS. The set consists of the Am79C30 Digital Subscriber Controller, the Am79C31A/312A Digital Exchange Controller, the Am79C32 ISDN Data Controller, and the Am7938 Quad Exchange Power Controller which works with the Am79C31A/312A. And it won't be long before we'll have protocol devices like the Am79C401 Integrated Data Protocol Controller.

Software made for our chip set.

Once you've got hardware, you'll probably be needing some software. That's easy. AMD has everything from low level device drivers to AmLINK, our LAPD software.

AmLINK implements software interfaces defined in the CCITT Q.921/931 recommendations. AmLINK is modular and it's independent of the operating system, giving you added flexibility. And, because you need it, source code is available.

We also provide well documented development boards that come complete with demonstration software. Understanding the capabilities, flexibility and functionality of complex ISDN chips has never been easier.

Field trial proven.

There's one more good reason why you should pick AMD. Our ISDN chips are in field trials with Illinois Bell, Mountain Bell, the Deutsche Bundespost and others. The chips were certified in field trial test beds. And they're still in use today.

Get in touch with AMD for more information. Then get your product off to a great start. And finish.

Advanced Micro Devices

901 Thompson Place, P.O. Box 3453, Sunnyvale, CA 94088
Call toll-free (800) 538-8450 ext. 5000; inside California call (408) 749-5000.

CIRCLE NO 103

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When you're trying to build the hottest new products you can think of, you need the latest, most sophisticated ASICs available. And the greatest number of ways to use them.

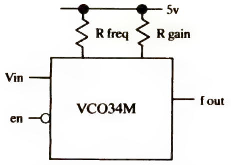
And that's the whole idea behind our Tripl
Technology.™ Which gives you the ability to
combine analog, digital, and E² cells all on t
same chip. And the confidence that they all

JUNE

VCO34M High Frequency VCO

Key Features:

	Min	Max	Units
Absolute Frequency	6	34	MHz
Center Frequency	12	30	MHz
Frequency Control Voltage, Vin	0.7	2.8	Volts
Adjustable Gain	1	10	MHz/Volt
Center Frequency Tolerance		10%	
Duty Cycle	40	60	%
Operating Power (f out = 30 MHz)		200	mW



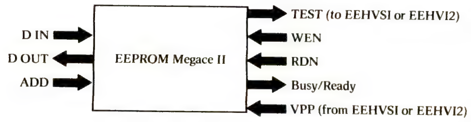
Coupled with its companion cell, CHGPMP, and digital phase detector logic, this 2 micron CMOS cell becomes the heart of a high-performance phase-locked loop subsystem on a chip. It allows integration of high speed analog functions such as data separators along with significant amounts of digital logic (>10K gates).

JULY

EEPROM Megacells

Key Features:

	Min	Max	Units
Memory Size	256	8192	(Bits)
Access Time		200	ns
Data Retention	10		years
Write Cycles	10,000		operations



These EEPROM Megacells feature standard serial test interface, auto power down after read or write, Busy/Ready handshake for simplified system write timing, built-in endurance/retention test, and are programmable from external or on-chip VPP supply. They are fully compatible with all the digital and analog cells in the Triple Technology™ 2 micron CMOS cell library.

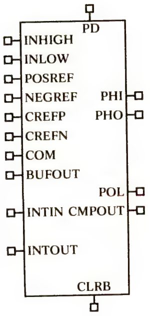
LY AS GOOD LAST IDEA.

ether, since they've all come from the same rce. Of course, we already give you the est cell library in the industry. But every nth this year, we'll use this space to introduce our latest ideas. To give you more possibilities than ever. If you'd like to see our complete library card, just write or call. In the meantime, just look what we've done for you lately.

AUGUST

ADC 12B 12 Bit Dual-Slope A/D Converter

ey Features:
- Accuracy
  - 12 Bit + Sign
- Operating Range
  - 5V ± 10% 0° to 70°C
- Conversion Rate
  - 3/Second
- Technology
  - 2μCMOS
- Power Down Current
  - <1μA
- Input Resolution
  - 50μV

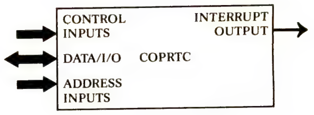


This new cell contains all the analog circuitry necessary o perform a 12 bit + sign conversion. The ADC 12 B's ower down feature makes it ideal for low-power transducer pplications. In addition it's integration-zero phase eliminates over-range "hangover" effects and crosstalk in multi-channel systems. The COPDAD version of this cell nterfaces directly with our COP800 core microcontroller.

SEPTEMBER

Real-time Clock for COP™ 800 Microcontroller Core

Key Features:
- Parallel interface to Sierra core cell
- Low power/independent operation
- Programmable interrupt system
- In-cell 32 KHz micropower crystal oscillator
- Timekeeping from 1/10 sec. to years
- Available in Sierra's 2-micron CMOS standard cell library.



The COPRTC Real time clock peripheral has a direct interface to the COP800. Its 32 KHz crystal oscillator allows independent operation while the controller core cell is in a low power halt state. The interrupt timer can "wake up" the controller at user programmable intervals. This peripheral keeps time with tenth second resolution and includes an automatic leap-year calculation. This cell represents only the latest demonstration of our commitment to introduce the highest performance cell-a-month throughout 1987.

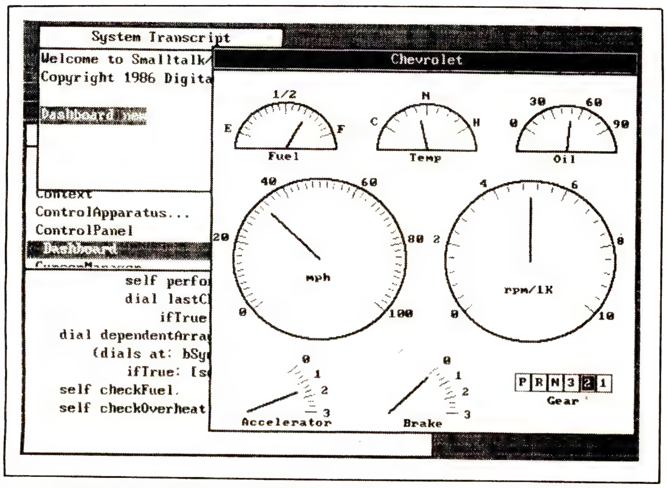
Sierra Semiconductor
Triple Technology.™ In CMOS.

2075 North Capitol Avenue, San Jose, California 95132. Telephone (408) 263-9300

CIRCLE NO 104

READERS' CHOICE

Of all the new products covered in EDN's **July 9, 1987,** issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **July 9, 1987,** issue.



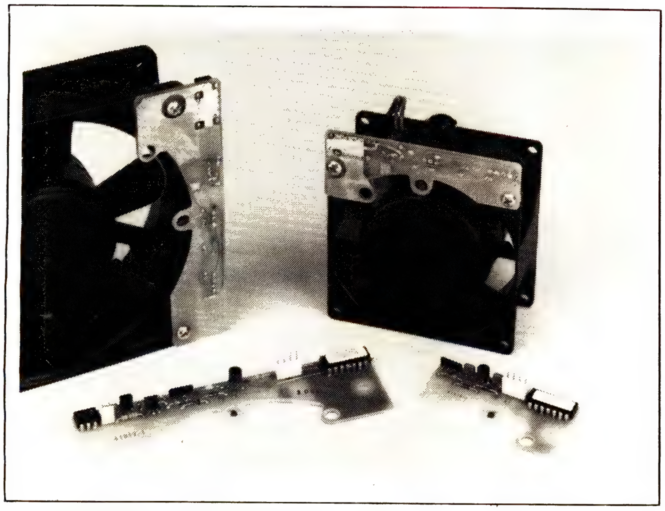
```
Welcome to Smalltalk/
Copyright 1986 Digita
```

```
            self perfo
            dial lastC
                ifTrue
    dial dependentArra
        (dials at: bSy
            ifTrue: [s
    self checkFuel.
    self checkOverheat
```

▲ SMALLTALK FOR PC

Smalltalk/V is a version of the Smalltalk object-oriented programming language that runs on IBM PCs and compatibles (pg 190).

Digitalk Inc.
Circle No 603



▲ SPEED CONTROLLER

The PC-DC is a speed controller that mounts directly on a small dc fan operating in a draw-through mode (pg 209).

Control Resources Inc.
Circle No 604

MOTOR-DRIVER ICs

The L6217 and L6217A stepper-motor driver ICs allow you to subdivide the motor's step interval into 64 or 128 microsteps, respectively (pg 124).

SGS-Microelettronica SpA.
Circle No 601
SGS Semiconductor Corp.
Circle No 602

▲ BACKUP BATTERIES

The μPowerCell lithium-iodine batteries have a 2.8V output and are available in various capacities—1Ahr (B-1000), 600 mAhr (B-600), and 400 mAhr (B-400) (pg 246).

Catalyst Research Corp.
Circle No 605

The new 60 MHz Tek 2221 (above) offers such features as CRT readout and measurement cursors for just $3995.

Now you have three low-cost choices in Tek digital storage oscilloscopes. All featuring powerful 20 MS/s *digitizing* along with familiar, full-bandwidth analog operation. It's the best of both worlds in one easy-to-use, portable package.

Discover the potential! With digital storage you can freeze waveforms. Capture events invisible to non-storage scopes. Find signals buried in noise. And build a library of reference waveforms.

CRT readout and cursors distinguish the new 2221. For even higher performance, there's the 100 MHz, dual time base 2230 with optional battery-backed memory for saving up to 26 waveform sets. And if it's economy you want, choose the 60 MHz 2220 with many of the same features at an even lower cost.

With each scope you can automate measurements with interface options. And output direct to a printer or plotter. Tek software is available for systems.

Features	**2230**	**● NEW! 2221**	**2220**
Analog/Digital Storage BW	100 MHz	60 MHz	60 MHz
Maximum Sampling Speed	20 MS/s	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K	4K
Peak Detect	100 ns	100 ns	100 ns
Save Reference Memory	One, 4K Three, 1K	One, 4K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over the bus)	8 bits 10 bits (AVG mode)	8 bits
CRT Readout/Cursors	Yes	Yes	No
GPIB/RS-232-C Options	Yes ($750)	Yes ($500)	Yes ($500)
Battery-Backed Memory (save 26 waveform sets)	Yes (inc with GPIB/RS-232-C)	No	No
Warranty	3 year on labor and parts, including the CRT		
Price	$4995	$3995	$2995

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CIRCLE NO 106

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Experts in the field present the theoretical and practical knowledge necessary for understanding and designing fiber optic communication systems. This book bridges the gap between classical communication practice and the new techniques required to design fiber optic communication systems. Engineering rules for designing systems are also given and supported by theoretical treatments. 256 pages, 1984.

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Practical and theoretical aspects of high bit rate systems (1 to 2 Gb/sec) for long-range transmission are explored in depth by noted West German scientists. The function of individual components as well as the system as a whole and performances of systems under study in several countries are examined. 224 pages, 1986.

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This new and revised edition provides the user with a broad spectrum of traditional and modern mathematical science data. New additions include: powers of numbers, sums of powers of the first *n* intergers, partial differential equations, factors for computing control limits, and mathematical symbols and abbrevations. 688 pages, 1987.

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100 MHz acquisition speed, or up to 2 channel data width cover demanding **state/time applications in digital ystems.**
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Powerful triggering and menu-driven peration combined with status display, screen prompts and fingertip control provide **easy user access to ull-function logic analysis.**

```
STATE PC      DISASSEMBLY
TRIG  000430 MOVEA.W #4007,A1   68000T
00004 000434 MOVE.B  #0098,D1      S/U
00006 000438 MOVE.B  D1,(A1)
      004007<98
00007 00043A RTS
      PC:FFC0B0>00000400
00012 000400 JSR        0430
      PC:FFC0B0<00000404
00014 000430 MOVEA.W #4007,A1
00018 000434 MOVE.B  #0098,D1
00020 000438 MOVE.B  D1,(A1)
      004007<98
00021 00043A RTS
      PC:FFC0B0>00000400
f1=Pos. Cursor f2=Spd: Slow f3=Cycles: on
```

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CIRCLE NO 105

LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	19	31	37	13	0	0	5.9	7.6
Pot-Core	11	22	45	22	0	0	7.7	6.8
Laminate (power)	20	13	54	13	0	0	6.7	10.7
CONNECTORS								
Military panel	33	0	67	0	0	0	5.3	16.2
Flat/Cable	21	54	17	8	0	0	4.3	4.1
Multi-pin circular	23	23	15	39	0	0	7.9	9.7
PC	33	11	45	11	0	0	5.6	9.7
RF/Coaxial	8	39	38	15	0	0	6.6	7.1
Socket	19	48	19	14	0	0	5.2	6.5
Terminal blocks	23	36	23	18	0	0	5.7	5.3
Edge card	22	33	28	17	0	0	5.8	6.3
D-Subminiature	13	34	40	13	0	0	6.3	8.6
Rack & panel	18	18	37	27	0	0	7.7	6.8
Power	30	20	20	30	0	0	6.9	8.8
PRINTED CIRCUIT BOARDS								
Single-sided	5	53	42	0	0	0	4.9	8.5
Double-sided	6	47	47	0	0	0	5.2	6.2
Multi-layer	0	21	63	16	0	0	8.1	9.5
Prototype	8	77	11	4	0	0	3.8	3.8
RESISTORS								
Carbon film	43	33	20	4	0	0	3.1	4.7
Carbon composition	50	27	15	8	0	0	3.2	3.7
Metal film	36	32	32	0	0	0	3.5	4.7
Metal oxide	40	40	20	0	0	0	2.8	5.9
Wirewound	15	37	26	22	0	0	6.6	6.0
Potentiometers	11	32	39	18	0	0	6.9	6.1
Networks	30	22	39	9	0	0	5.1	6.9
FUSES	50	28	22	0	0	0	2.6	4.7
SWITCHES								
Pushbutton	19	24	52	5	0	0	5.6	5.6
Rotary	6	25	63	6	0	0	6.7	6.5
Rocker	21	36	36	7	0	0	5.0	6.4
Thumbwheel	13	31	44	23	0	0	6.4	7.7
Snap action	24	29	35	12	0	0	5.5	6.4
Momentary	25	17	50	8	0	0	5.8	6.7
Dual in-line	18	27	46	9	0	0	5.9	7.5
WIRE AND CABLE								
Coaxial	40	40	20	0	0	0	2.8	3.6
Flat ribbon	29	38	29	4	0	0	4.1	4.2
Multiconductor	40	20	40	0	0	0	3.8	5.0
Hookup	61	30	9	0	0	0	1.6	3.2
Wire wrap	26	19	55	0	0	0	5.0	4.3
Power cords	36	32	20	12	0	0	4.4	5.9
POWER SUPPLIES								
Switcher	11	22	56	5	6	0	7.4	8.0
Linear	0	27	53	20	0	0	8.2	8.6
CIRCUIT BREAKERS	11	33	28	28	0	0	7.5	6.0
HEAT SINKS	22	48	17	13	0	0	4.8	4.4
RELAYS								
General purpose	35	20	20	25	0	0	6.1	7.0
PC board	16	26	32	26	0	0	7.4	10.7

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
Dry reed	17	25	25	33	0	0	7.9	8.9
Mercury	14	29	29	29	0	0	7.6	8.8
Solid state	27	27	26	20	0	0	6.0	7.9
DISCRETE SEMICONDUCTORS								
Diode	35	14	19	21	11	0	8.0	7.2
Zener	24	28	17	28	3	0	7.4	7.4
Thyristor	31	25	13	31	0	0	6.6	8.7
Small signal transistor	39	13	30	18	0	0	5.5	8.1
MOSFET	25	21	37	17	0	0	6.2	8.9
Power, bipolar	26	30	31	13	0	0	5.4	10.3
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	11	26	11	37	10	5	11.7	9.3
CMOS	17	22	22	35	4	0	8.9	9.9
TTL	29	19	28	24	0	0	6.5	9.1
LS	33	13	29	25	0	0	6.6	8.7
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	23	31	23	23	0	0	6.3	8.0
OP amplifier	13	25	33	29	0	0	7.9	8.9
Voltage regulator	16	28	36	20	0	0	6.8	8.4
MEMORY CIRCUITS								
RAM 16k	25	25	8	42	0	0	7.9	11.3
RAM 64k	16	32	10	42	0	0	8.3	11.3
RAM 256k	14	36	14	36	0	0	7.8	11.6
RAM 1M-bit	0	67	0	17	16	0	8.8	12.6
ROM/PROM	8	33	25	25	9	0	9.0	13.4
EPROM 64k	22	22	6	44	6	0	9.4	12.0
EPROM 256k	6	44	13	31	6	0	8.8	12.1
EPROM 1M-bit	0	0	38	50	12	0	13.9	15.1
EEPROM 16k	13	12	13	50	12	0	12.3	12.6
EEPROM 64k	9	18	9	46	18	0	13.0	13.4
DISPLAYS								
Panel meters	9	27	55	9	0	0	6.6	8.5
Fluorescent	0	33	17	50	0	0	10.1	10.5
Incandescent	0	33	50	17	0	0	7.6	6.8
LED	17	33	42	4	4	0	6.0	7.3
Liquid crystal	5	18	41	32	4	0	9.9	8.8
MICROPROCESSOR ICs								
8-bit	20	0	47	33	0	0	8.9	8.4
16-bit	21	7	43	29	0	0	8.1	11.1
32-bit	8	39	23	23	7	0	8.5	10.4
FUNCTION PACKAGES								
Amplifier	17	33	17	33	0	0	7.5	7.6
Converter, analog to digital	13	31	19	37	0	0	8.3	8.8
Converter, digital to analog	13	34	13	40	0	0	8.3	9.5
LINE FILTERS	20	20	27	33	0	0	7.9	11.3
CAPACITORS								
Ceramic monolithic	31	28	17	24	0	0	5.9	5.6
Ceramic disc	27	28	24	21	0	0	6.0	5.2
Film	19	27	31	19	4	0	7.3	6.4
Aluminum electrolytic	17	21	28	34	0	0	8.2	7.8
Tantalum	22	25	22	31	0	0	7.3	7.4
INDUCTORS	21	42	16	21	0	0	5.8	8.0

Source: *Electronics Purchasing* magazine's survey of buyers

One Hybrid Solitron Can't Build.

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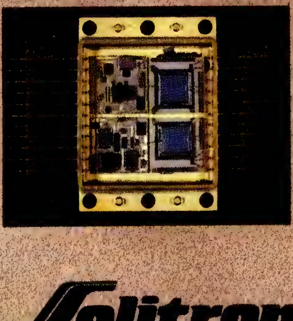

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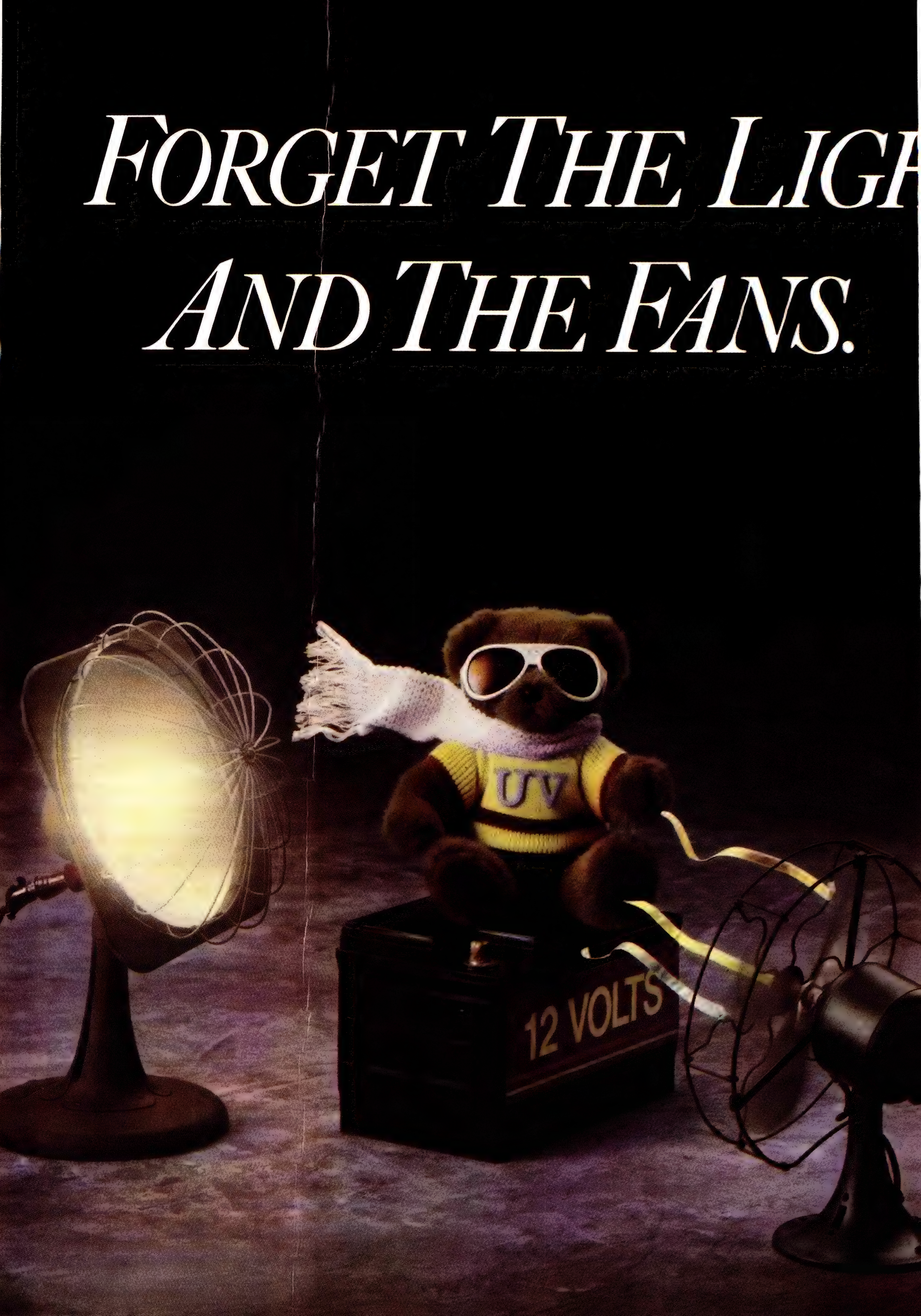
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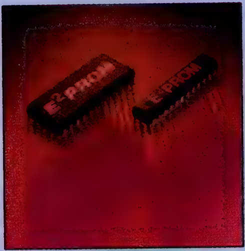

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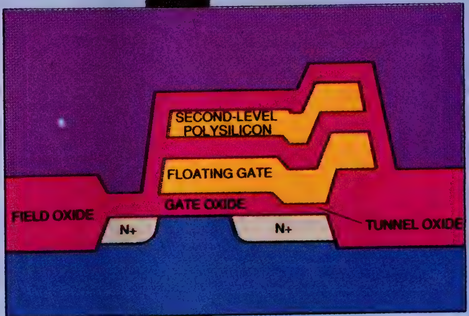

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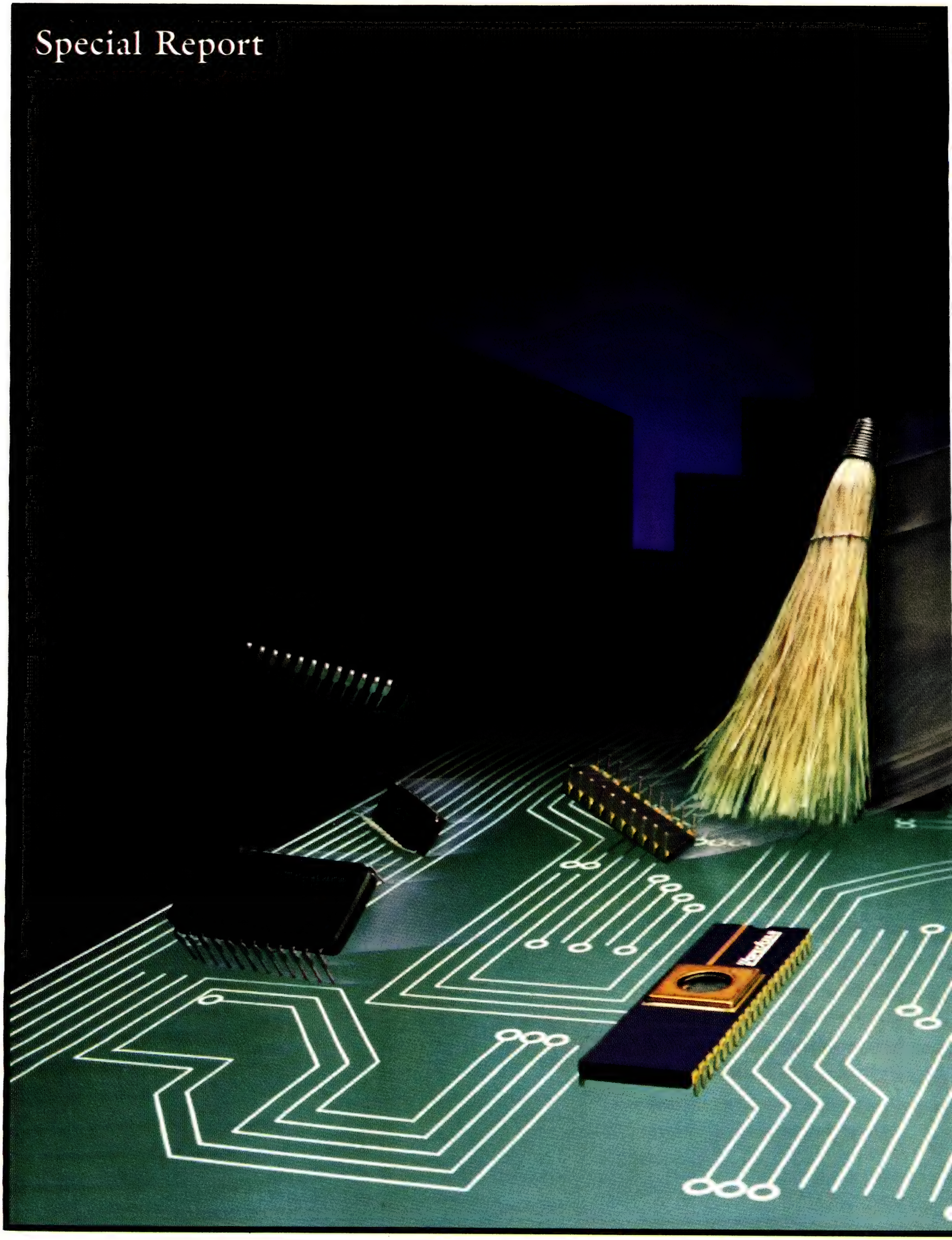


***Today's high-speed CMOS EPROMs** sweep away the high-speed static RAMs previously required to hold code downloaded from slow EPROMs. (Photo courtesy Waferscale Integration; concept by Imagination)*

High-speed EPROMs

Today's high-speed EPROMs can deliver access times ranging from 100 to 25 nsec, and the faster of these CMOS EPROMs fit into designs that previously required bipolar PROMs. Also, thanks to these new ICs, designers can implement no-wait-state nonvolatile memory in 20- to 30-MHz μP-based systems.

Maury Wright, *Regional Editor*

You may be used to reading headlines touting 1M-bit (and larger) EPROMs, but the new generation of high-speed EPROMs is equally important. Recently introduced CMOS devices, in fact, specify access times as low as 25 nsec. These nonvolatile-memory ICs fit applications such as bit-slice designs, which previously required the speed you could only find in bipolar fuse-link PROMs. When designing DSP and general-purpose μP-based systems, you can use EPROMs with access times of 100 nsec and less to implement a design with zero-wait-state memory accesses, even as μP clock speeds reach 30 MHz and faster.

Although the scope of this report is limited to high-speed EPROMs, semiconductor manufacturers are pursuing two other developments in EPROM technology as well: the above-mentioned high-capacity EPROMs and EPROMs combined with specialized logic. Of course, vendors are also interested in related nonvolatile-memory technology such as EEPROMs. Nonetheless, the development of high-capacity EPROMs does have a bearing on the development of high-speed EPROMs—for reasons that will become clear as you read this article.

If you consider the semiconductor market as a whole, EPROM sales volumes are second only to dynamic RAMs. Consequently, EPROMs serve as a proving ground for new semiconductor processes. Traditionally, the larger vendors have been interested primarily in developing high-capacity, high-volume commodity parts. Production-quantity shipping of 1M-bit EPROMs began this year, and the first 4M-bit parts will appear in 1988.

You can expect these same commodity manufacturers to begin offering EPROMs with on-chip logic for specific applications. They plan to build EPROMs for specific applications much the way they designed dynamic RAMs for video applications and other niches. In fact, a few companies already offer products specific to certain applications (see **box**, "EPROMs with application-specific logic emerge").

It's only been during the last couple of years that IC manufacturers have concerned themselves with high-speed EPROMs, and even now, few commodity-EPROM manufacturers participate in this market segment. By the middle of next year, however, you can expect all the major EPROM manufacturers to introduce sub-100-nsec parts.

The first available high-speed EPROMs targeted applications normally served by bipolar PROMs. These EPROMs serve in applications such as

CMOS EPROMs with access times as low as 25 nsec can directly replace bipolar PROMs in existing designs and can even match the bipolars' fanout specs.

control stores in bit-slice-based designs and in state-machine implementations replacing random logic. Such EPROMs typically feature access times from 60 to 25 nsec. The CMOS parts are pin-for-pin compatible with existing bipolar PROMs; indeed, they even meet the fanout specs of the bipolar devices. Thus, you can substitute the CMOS EPROMs for bipolar PROMs in existing designs.

Texas Instruments was the first major EPROM manufacturer to enter the high-speed market; in the first quarter of this year, the company introduced the 16k-bit TMS27C291/292. The former is enclosed in a 300-mil DIP, and the latter comes in a 600-mil DIP. The company offers the parts with 35-, 45-, and 50-nsec access times, and it plans to offer a PLCC version later this year. As a frame of reference, a 45-nsec TMS27C292 costs $9.73 (100).

CMOS EPROMs replace bipolar PROMs

The TMS27C291/292 are direct replacements for standard bipolar PROMs. According to marketing manager Pradeep Shah, Texas Instruments should have a 64k-bit device available around the end of the year. Shah explains that the company used proven technology to achieve the fast access times. The parts are constructed with 2-µm CMOS technology; the memory array uses a folded-cell configuration, and each cell has two transistors with differential sensing. (Traditionally, commodity EPROMs employ a single-transistor cell.) Because of its differential cell, the sense amp can detect a programmed or unprogrammed state with less voltage swing and therefore a faster access time.

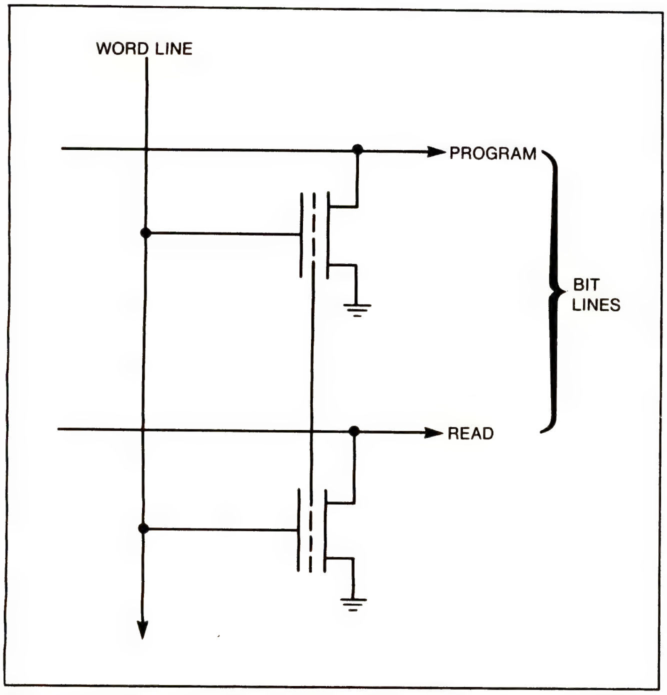


Fig 1—Separate read and program transistors *in Cypress's EPROM cells result in access times as low as 40 nsec and ensure reliable programmability.*

International CMOS Technology also uses a differential cell in the EPROMs it offers as bipolar-PROM replacements. Available with access times spanning 35 to 55 nsec, the 27CX321/322 and 27CX641/642 store 32k and 64k bits, respectively. The ICs feature a ×8 organization and come in 600- or 300-mil DIPs. A 45-nsec 27CX641-45 costs $49.80 (100); a 55-nsec version costs $41.50 (100).

The EPROMs mentioned above, and in fact all the EPROMs discussed in this article (unless otherwise noted), are enclosed in windowed ceramic packages. Even the 300-mil devices include a window and are programmable and erasable (just like commodity EPROMs). You simply need an ultraviolet-light eraser and a properly configured standard EPROM programmer. Some of the devices are also available in windowless ceramic and plastic one-time-programmable packages.

Cypress marketing manager Tom North sees several advantages to using CMOS EPROMs in place of bipolar PROMs. He says that the CMOS parts result in a power savings of at least 50% compared with bipolar equivalents. They cost approximately the same as their bipolar counterparts, but they save you money because of their reduced power consumption—especially where new designs are concerned.

Power-down mode favors CMOS EPROMs

According to North, you can realize even greater power savings when you choose a part with a power-down mode. Of Cypress's broad range of bipolar-replacement EPROMs (4k to 128k bits), several offer a reduced-power mode. The CY7C251, a 128k-bit (16k-byte) device, consumes 550 mW when operating and 165 mW when the chip-select input isn't active. The part costs $97.20 (100), comes in a 300- or 600-mil DIP, and features a 45-nsec access time. The 8k-byte CY7C261 has similar power specs; a 40-nsec version costs $52.55 (100). Few bipolar PROMs offer a power-down mode, and the ones that do suffer from a delayed access when the chip-select input is activated.

Cypress uses a 4-transistor cell in its 4k-, 8k-, and 16k-bit parts and a 2-transistor cell in its higherapacity EPROMs. Rather than taking a differential-ransistor approach, the 2-transistor cell allocates one ransistor for the programming function and one tranistor for the read function (**Fig 1**). The floating gates f the two transistors are connected. The 4-transistor ell also splits the read and programming functions, but mploys differential transistors for both tasks. North laims that higher capacities require reduced cell size nd therefore fewer transistors to maintain economical ie sizes; for this reason, the company has committed tself to the 2-transistor cell approach.

Cypress also offers 4k-, 8k-, and 16k-bit parts with output latches (also called registered EPROMs). The CY7C245 16k-bit (2k-byte) device, which costs $39.55 (100), includes an output latch and an initialization feature. The output latch serves applications such as synchronized pipelined system designs; designs such as state machines use the initialization byte to begin operation. A single input pin controls the loading of the initialization byte into the output latch. The initialization feature essentially adds one extra byte of storage to the EPROM array. Other registered EPROMs include the CY7C225/235 4k- and 8k-bit parts, which cost $13.05 and $11.65 (100), respectively. These devices

EPROMs with application-specific logic emerge

IC manufacturers have begun to add logic to their EPROM arrays and to target the finished products at specific applications. Manufacturers have seen many application-specific RAM niches materialize and envision a similar scenario for EPROMs. The first products include relatively little logic, but you can anticipate that this situation will change as manufacturers devise new applications.

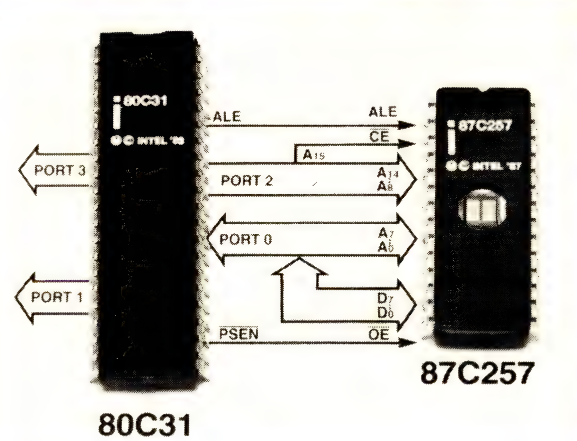
Intel has led the way in providing EPROMs that include specialized functions. Consider the 27513 512k-bit page-addressable EPROM. The device's paged organization allows four 128k-bit pages to be mapped into a single 128k-bit address space. The EPROM can directly replace a 27128 and quadruple the storage capacity with only firmware changes to the design required. It costs $11 (10,000).

Take your pick

For users of μPs with multiplexed data and address buses, Intel offers the 87C257 and 68C257 256k-bit EPROMs. The former interfaces to Intel single-chip μCs; the latter, to Motorola single-chip μCs without any glue logic. The EPROMs are priced at $8.50 and $8.80 (10,000), respectively. Fujitsu (Santa Clara, CA) plans to introduce a product similar to these next quarter. The company will offer versions with ×8 and ×16 organizations.

Texas Instruments has taken a different approach to adding logic to EPROM arrays. According to marketing manager Pradeep Shah, customers specify the logic to be added, much like they do when designing a semicustom IC. Shah explains that, if you need a lot of logic and a small memory array then you're better off with a standard-cell or gate-array approach, but if you need a large EPROM array with some added logic, you can have Texas Instruments customize the chip for you.

So far the company has added logic to an EPROM for demultiplexing a data/address bus like the Intel chip does; in other cases, it has added registers and control logic to EPROMs. The company will not quote prices, but you can expect to pay some nonrecurring-engineering (NRE) costs and a premium per IC unless you buy in large quantities.



By combining logic with an EPROM array *on the 87C257 and 68C257, Intel provides an EPROM that interfaces to popular single-chip μCs with no external logic.*

Major semiconductor manufacturers have begun to introduce devices that are pin compatible with commodity EPROMs, yet feature access times of less than 100 nsec.

come only in plastic one-time-programmable packages.

Cypress breaks the access-time spec for its registered EPROMs into two parts. The CY7C245, for example, has a 25-nsec setup time and a 12-nsec clock-to-output time. Pipelined systems that use registered EPROMs typically rely on the clock-to-output spec to derive performance.

The manufacturer offers nonregistered 8k- and 16k-bit EPROMs, too. The 30-nsec plastic CY7C281 stores 1k byte and costs $6 (100). The 35-nsec, 2k-byte CY7C291 costs $12.75 (100) in a windowed ceramic package or $9.75 (100) in plastic.

Access time to reach 20 nsec this year

According to North, Cypress plans to have some of its EPROMs available with 20-nsec access times by the end of this quarter. He believes it will be a couple of years before CMOS EPROMs can reliably and economically offer access times of less than 20 nsec. (If and when available, however, designers could use 10- to 15-nsec EPROMs for logic replacement.)

Not surprisingly, Cypress also plans to expand its product line with higher-capacity, high-speed EPROMs; a 55-nsec, 256k-bit part, for example, should appear early next year. Such higher-capacity devices exceed the capacity of currently available bipolar PROMs. Fortunately, however, the JEDEC standards committees have defined pinouts for yet-to-be-announced higher-capacity PROMs, and the EPROMs will fit these standard pinouts and packages.

Your EPROMs don't have to match the bipolar PROMs' packages. The planned 64k-, 128k-, and 256k-bit capacities of the high-speed EPROMs are the same as the popular commodity EPROMs. JEDEC standards for commodity-EPROM pinouts and packages do differ from JEDEC bipolar-PROM standards, but you can actually use either pinout in a design. Designers are in the habit of using the commodity-EPROM standard pinout with microprocessors.

TABLE 1—ZERO-WAIT-STATE REQUIREMENTS

μP	CLOCK FREQUENCY	MAX EPROM ACCESS TIME
80386	16 MHz	70 nSEC
68020	20 MHz	70 nSEC
32020	20 MHz	75 nSEC
56000	20 MHz	55 nSEC
320C25	40 MHz	40 nSEC

In general, the large semiconductor manufacturers plan to build high-speed EPROMs that are identical to their existing commodity-EPROM product lines. The advent of general-purpose and DSP μPs with clock frequencies exceeding 20 MHz has prompted the need for faster EPROMs. To maximize system performance, designers are intent on ways to ensure zero-wait-state access between the μP and memory (including EPROMs). Without high-speed EPROMs, they'd be forced to implement schemes to download code from slow EPROMs to fast static RAM. **Table 1** lists the EPROM access times required to provide zero-wait-state memory access with some popular μPs.

The rush by commodity-EPROM manufacturers to provide high-speed, high-capacity parts has already begun. New commodity-EPROM designs will specify 150 nsec as the slowest acceptable speed. The 128k-bit Intel HMOS 27128B, for example, provides a 110-nsec access time and costs $13.30 (100).

Another major vendor, Hitachi, has introduced the HN27C256HG, a 256k-bit device capable of 70- or 85-nsec access times. A 70-nsec version costs $15 (5000). General Instrument has similar plans for its CMOS product line. You can buy the 70-nsec 64k-bit 27HC64

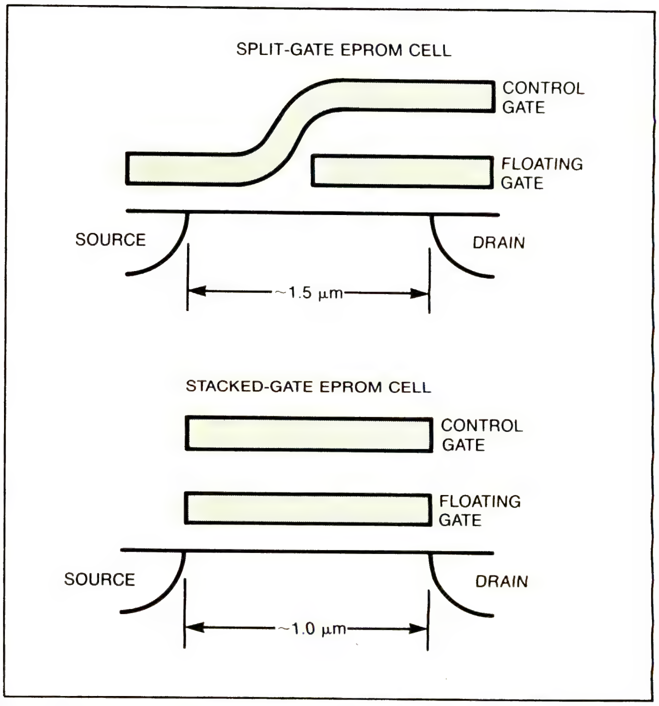


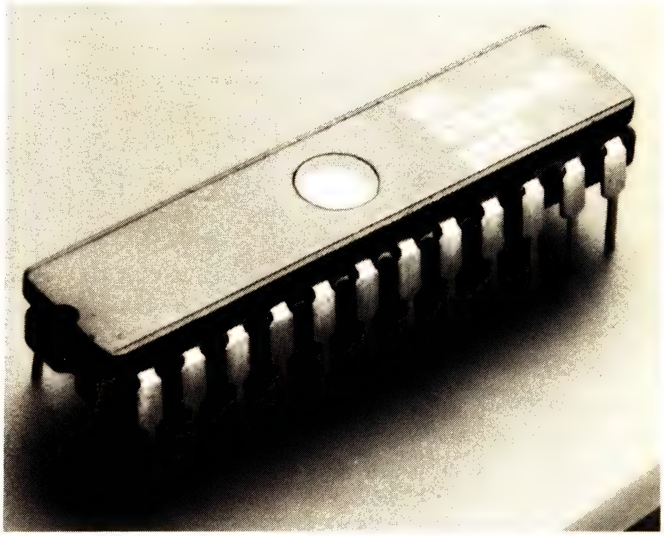
Fig 2—The single-transistor split-gate cell, *which Waferscale uses in its EPROMs, provides sub-100-nsec access times and is only marginally larger than the stacked-gate cell found in industry-standard commodity EPROMs.*

for $19.50 (1000); a 45-nsec version will soon be available. By the end of the year, General Instrument also plans to have 256k-bit EPROMs with access times ranging from 55 to 90 nsec.

As you well know, commodity-EPROM manufacturers have spent years tuning their designs for maximum capacity. Thus far, these manufacturers have attempted to speed up the parts without making radical changes to the industry-standard, single-transistor, stacked-gate cell. The smaller specialty EPROM manufacturers, however, entered the market with well-defined high-speed design goals.

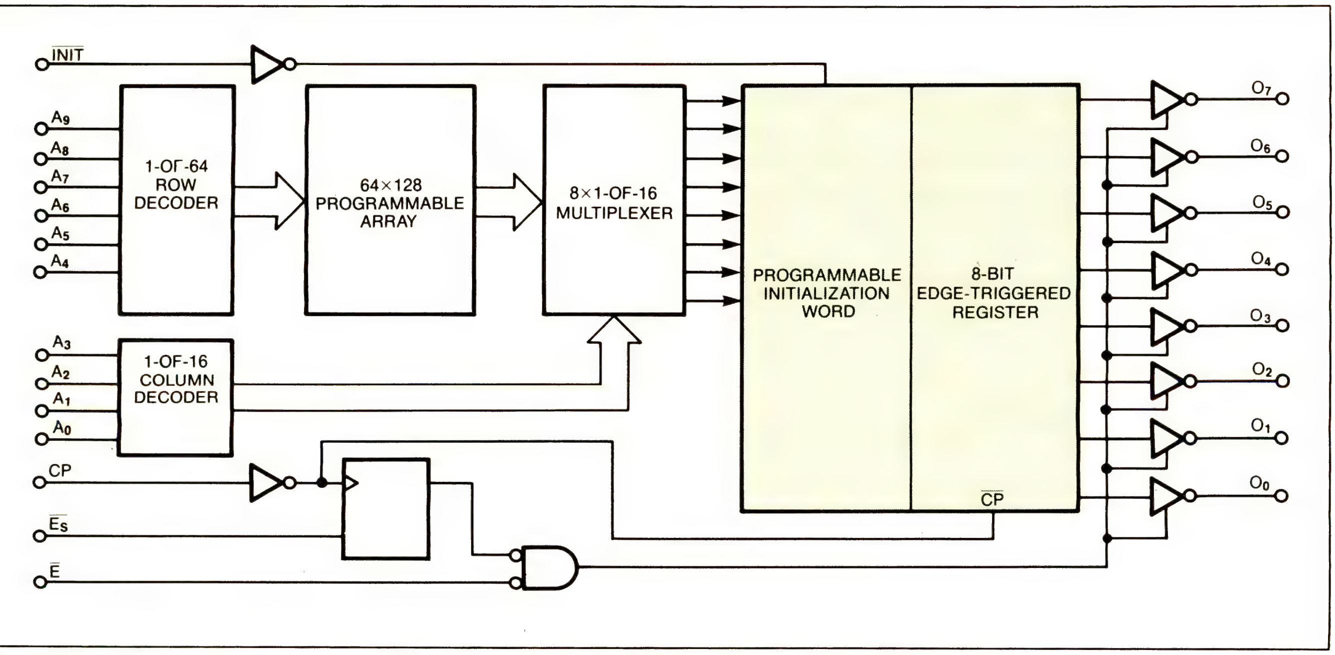
Split-gate cell provides speed

Waferscale Integration, for instance, claims to have achieved its array-capacity, access-speed, and programming-reliability goals by perfecting a single-transistor cell. **Fig 2** depicts a standard stacked-gate cell and Waferscale's split-gate cell. The split-gate cell increases read currents and therefore provides access times as low as 35 nsec. According to Dale Prull, Waferscale's director of corporate communications, the company's IC designers wanted to use a single-transistor cell to ensure that they could economically build a large array. The company plans to build a 1M-bit EPROM with the split-gate cell structure.



The 8k-byte 300-mil-DIP *WS57C49B from Waferscale provides an alternative to bipolar PROMs and features access times as low as 35 nsec.*

It has used the split-gate cell in EPROMs that comply with both bipolar-PROM and commodity-EPROM packaging standards. The bipolar-PROM replacements come in capacities ranging from 16k to 128k bits. All of the devices feature ×8 organizations and are available in windowed 300-mil and 600-mil ceramic DIPs and leadless ceramic chip carriers. The 16k-bit WS57C191/291 (45 nsec), 32k-bit WS57C43 (55 nsec), 64k-bit WS57C49



An output latch and an initialization feature *make the Cypress CY7C225/235/245 EPROMs suitable for implementing state-machine designs.*

The need for fast µPs to do zero-wait-state memory accesses has played a major role in driving high-speed EPROM technology.

(55 nsec), and 128k-bit WS57C51 (70 nsec) cost $9.75, $24.50, $23, and $50 (100), respectively.

The company's EPROMs that meet the commodity-EPROM pinouts all have 55-nsec minimum access times. For 64k-bit needs, you can choose the 8k×8-bit WS57C64F or the 4k×16-bit WS57C65. The parts cost $23 and $31 (100). The 128k-bit WS57C128F has a byte-wide organization only; it costs $50 (100). The 256k-bit WS57C256F and WS57C257 each cost $90 (100) and are organized as 32k×8 and 16k×16 bits, respectively.

Atmel Corp also sells CMOS EPROMs for both commodity-EPROM and bipolar-PROM pinouts. The $43.76 (100) 64k-bit 27HC64 complies with the standard 28-pin commodity package and specs a 45-nsec access time. The 64k-bit 27HC641/642 parts, also featuring 45-nsec access times, come in bipolar-compatible 300- and 600-mil DIPs and sell for $38.44 (100). The 55-nsec, 256k-bit commodity-EPROM-compatible 27HC256 costs $74.17 (100).

Designers need fast EEPROMs to implement zero-wait-state systems just like they need fast EPROMs. Applications such as aerospace and telecommunications demand designs allowing new code to be loaded into a system without replacing modules or semiconductors. Such applications also justify the 3 to 5× price premium for EEPROMs as compared with EPROMs. Jim Oliphant, Xicor's director of marketing, claims that in any design you can justify the cost of an EEPROM vs an EPROM if at least one field upgrade is required. With EEPROMs, you can easily design a system that can be updated without disassembly.

Atmel has been able to combine its high-speed cell technology with its EEPROM expertise to achieve fast access times, thanks in part to its single-transistor stacked-gate cell, 2-layer metal, and sense-amp design. The 2k×8-bit 28HC16 EEPROM has a 45-nsec access time, complies with the standard commodity-EPROM pinout, and costs $17.16 (100). The 35-nsec 28HC191/291 EEPROM features a similar 2k×8-bit organization in a 300- or 600-mil bipolar-replacement package and costs $12 (100). The manufacturer also offers a 64k-bit EEPROM, the 28HC64. This device is compatible with the standard-EPROM pinout and is priced at $85.80 (100). Its access time is 55 nsec. The company plans to introduce a 90-nsec, 256k-bit EEPROM within the next quarter.

Xicor's X2864H 64k-bit EEPROM comes in a 90-nsec version for $85.25 (100) or a 70-nsec version for $120.81 (100). In addition, Seeq has 16k- and 32k-bit, 35-nsec EEPROMs that offer both standard-EPROM pinouts and bipolar-PROM pinouts. The 2k×8-bit 36C16 and 4k×8-bit 36C32 EEPROMs are housed in 300-mil DIPs. The 36C16 costs $18; the 36C32 costs $30 (100). The 38C16 and 38C32 provide identical organizations in standard EPROM packages and cost $27 and $38 (100), respectively. **EDN**

Article Interest Quotient (Circle One)
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Manufacturers of high-speed EPROMs

For more information on the high-speed EPROMs such as the ones discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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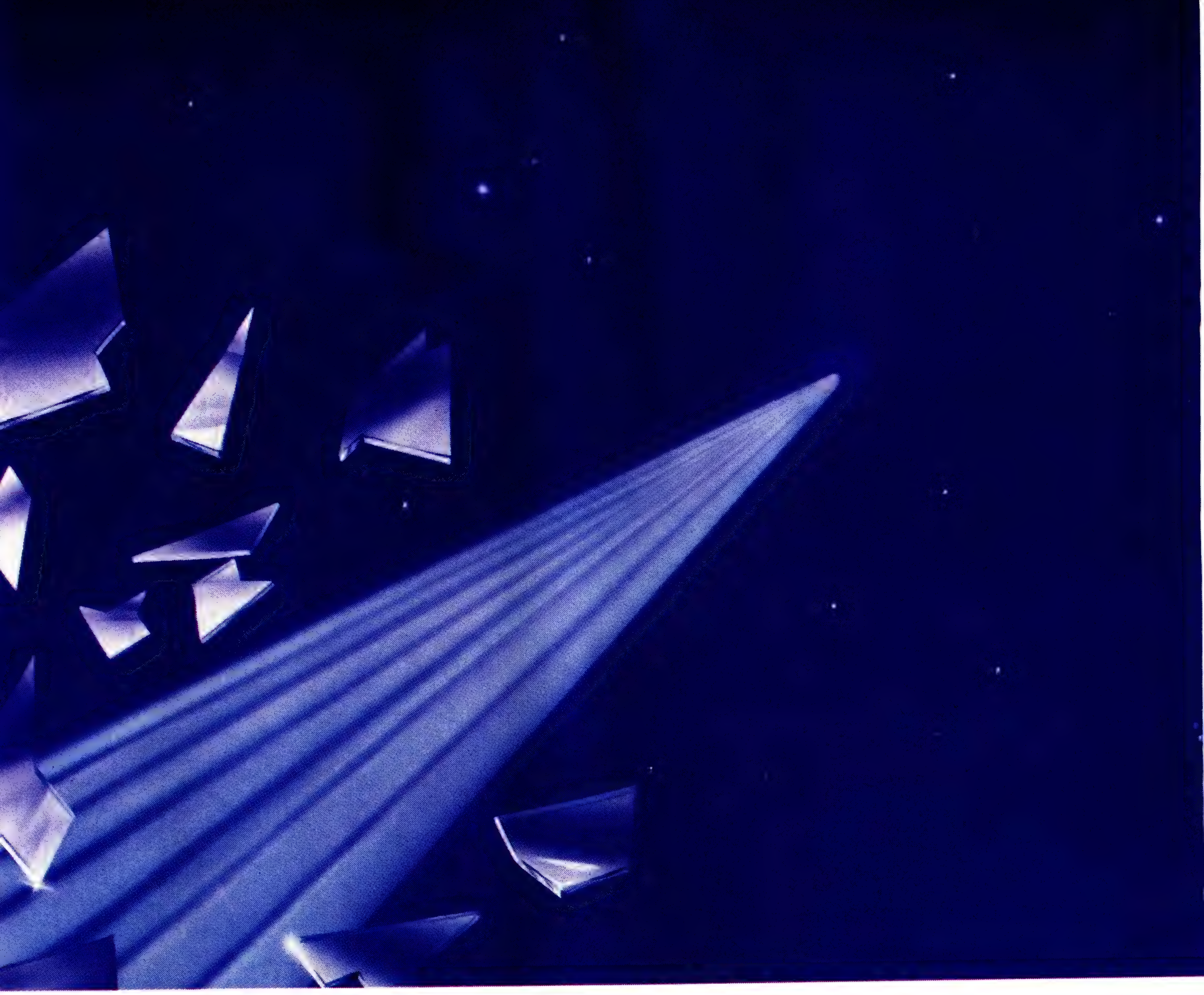
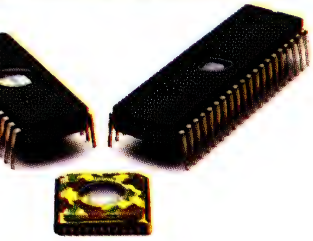
CIRCLE NO 72

WaferScale 55ns 256K CMOS EPROMs Shatter the Speed Barrier.





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x 8 in 55 ns.
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WS57C257	55 ns	70 ns	16K x 16 CMOS EPROM
WS27C256F	90 ns	90 ns	32K x 8 CMOS EPROM
WS57C65	55 ns	70 ns	4K x 16 CMOS EPROM
WS57C64F	55 ns	70 ns	8K x 8 CMOS EPROM
WS57C49	55 ns	70 ns	8K x 8 CMOS EPROM
WS57C49B	35 ns	45 ns	8K x 8 CMOS EPROM
WS57C43	55 ns	70 ns	4K x 8 CMOS EPROM
WS57C191/291	45 ns	50 ns	2K x 8 CMOS EPROM

WaferScale
INTEGRATION, INC.

47280 Kato Road
Fremont, California 94538
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CIRCLE NO 73

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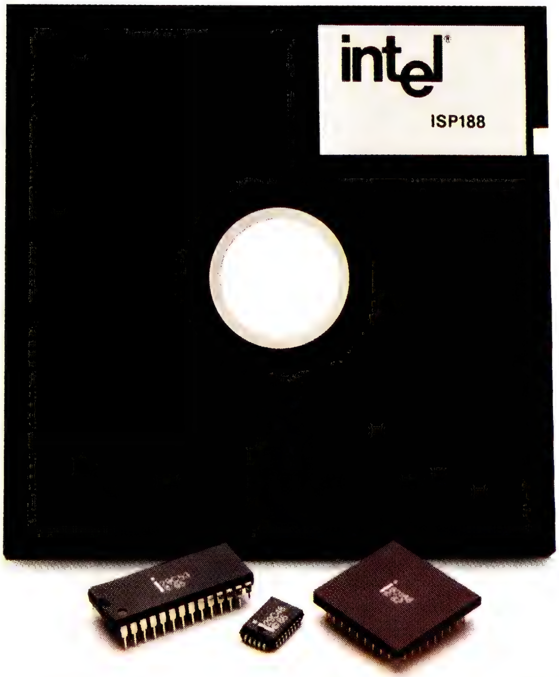
COMPLETE.



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CIRCLE NO 111

32-bit single-board computers come close to mainframes' capability

Thirty-two-bit microprocessors are bringing mainframe-like power to single-board computers. In EDN's first directory of 32-bit-CPU boards, you'll find numerous boards based on a couple of different μPs. The directory tables begin on pg 152.

John Gallant, *Associate Editor*

The incorporation of 32-bit microprocessors into board-level products is giving system integrators reason to pause when considering design tradeoffs. Many of the features previously available only with large computer systems are now available on single-board computers. Some boards, for instance, utilize fast real-time multitasking kernels for use in multiprocessing environments, and various versions of Unix—or Unix-type operating systems—support multiuser environments.

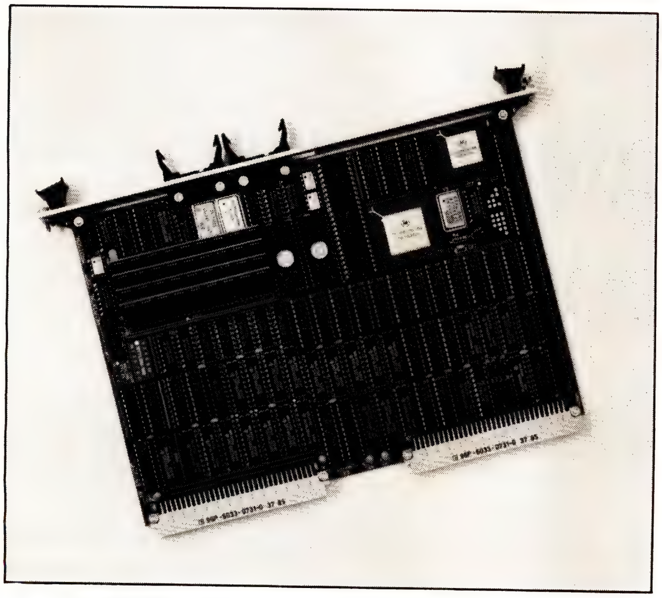
Most 32-bit-CPU boards are resplendent with coprocessors, memory-management units, onboard RAM, and sockets for ROM or EPROM. Also, combinations of interrupt mailboxes and dual-ported memories allow for message passing in multiprocessing or parallel-processing systems. Many boards contain disk-drive interfaces and I/O ports (serial and parallel), making them, in effect, stand-alone minicomputers. Some even operate at the maximum speed capabilities of the resident microprocessors.

This directory is the result of a survey of 32-bit-CPU board manufacturers. According to respondents, the VME Bus is the most popular choice for 32-bit-CPU board designs, and the Motorola 68020 is the preferred 32-bit microprocessor. Thanks to the VME Bus's full 32-bit architecture (data and address lines), along with its other sophisticated features, designers can achieve high-performance platforms.

As you study the directory tables (which begin on pg 152), be careful when comparing cost. Board prices vary considerably according to clock speed and the amount of onboard memory. You'll incur lower costs for each added option. A good example is Heurikon's HK68/V2F, a double-height Eurocard board for real-time applications. The board sells for $1695 in its stripped-down version: a 68020 running at 12.5 MHz, 128k bytes of EPROM, and 256k bytes of onboard dual-access dynamic RAM. It has full master/slave interfaces to the VME Bus; incorporates an RS-232C port driven from a 68901 multifunction peripheral chip; includes mailbox interrupts; and supports VRTX32, PSOS, and OS-9. For an additional $3550 (a total of $5245), you can get the board with a 25-MHz 68020 CPU, 4M bytes of dynamic RAM, a 68881 FPU (floating-point processor), and a real-time clock.

Boards that support Unix operating systems tend to be more expensive. The HK68/20, similar to the stripped-down HK68/V2F except that it also supports

A dual-ported memory with mailbox interrupts enables fast data and message exchange between boards on the bus.



***The HK68/V2F board,** manufactured by Heurikon, has a 12.5-MHz 68020 and 256k bytes of onboard dynamic RAM. It sells for $1695.*

Unix System V.2 with Berkeley enhancements, sells for $2795. (The HK68/20 has a place for a 68851 PMMU, which will cost you an additional $695.)

Another representative example is the Ironics IV-3204 VME Bus multiprocessing engine, which is configured in a double Eurocard format. It contains a 68020 µP running at 16.7 or 20 MHz with an optional 68851 PMMU or 68881 FPU. The price is $4210 (16-MHz version) or $4995 (20-MHz version). It has 4M bytes of onboard RAM, allowing execution of an entire Unix V.2 kernel and user programs without bus accesses. A dual-ported memory with mailbox interrupts permits fast data and message exchange between boards on the bus.

The IV-3204 also contains a socket that can hold as much as 64k bytes of EPROM or ROM for resident software. It operates with full master/slave interfaces and supports VME Bus interrupts via a 68155 interrupt handler. In addition, it can function as the primary master to a VMX Bus interface.

If you want a SCSI interface

Another board for the VME Bus, Basu/Dage Precision Industries' CPU 20, includes provision for a SCSI interface. It comes with a 68020 operating at either 12.5 or 16.7 MHz, and it has a 1M-byte dynamic RAM and a 1k-byte dual-ported RAM mailbox. A 32-pin socket can house 1M bytes of EPROM. Along with the SCSI interface, a parallel port for handling 23 I/O lines and 2 RS-232C ports are also included. A 4-level, priority-controlled bus arbiter supports multiprocessor functions; you also have a round-robin option and an onboard requester with release-when-done or release-on-request options. The board runs on Unix V.2, P-DOS, and OS-9, and it is configured in the Eurocard double-height format. The 12.5-MHz version sells for $3290; the 16-MHz version costs $4175.

In this directory you'll also find 32-bit boards available for VME Bus embedded-controller applications. Motorola's MVME133A-20 combines a 20-MHz 68020 CPU with a 68881 FPU. The board supports the VersaDOS real-time operating system, which incorporates drivers for Motorola's VME-module peripheral-controller boards. It contains 1M bytes of onboard dynamic RAM. A multiport arbiter allows the CPU, the refresh circuitry, and the VME Bus to access the RAM. The board acts as a VME Bus master only and uses address modifiers to indicate privilege when the dynamic RAM is being accessed and when the board isn't the current VME bus master. A Z8530 serial communications controller implements two multiprotocol serial ports, and a front-panel debug port provides general-purpose I/O. A real-time clock (58274) provides time-keeping functions (tenths of seconds to tens of years). The board is configured in a Eurocard double-height format and sells for $3585.

Increasing access time isn't too difficult

Some applications demand more memory than the board has space for. For these cases, some boards include local extension interfaces right on the card to increase memory-access times. These interfaces can be piggyback-type connections to daughter boards containing high-speed static RAM or special connections to neighboring static-RAM boards.

The Force SYS68K/CPU-21B, which uses a 68020 to achieve 25-MHz zero-wait-state operation, has a 32-bit-wide 96-pin DIN connector located on the middle of the board. Called the Force Local Memory Extension (FLME), it can connect the CPU to a full megabyte of static RAM (two companion boards, each containing 64 64k-byte static RAMs). The SYS68K/CPU-21B is configured as a double-height Eurocard.

The GMSV07 from General Micro Systems also operates with a 68020 at clock speeds to 25 MHz, but it has 512k bytes of zero-wait-state static RAM on board with an extra 1M bytes possible via a plug-in daughter board. This mezzanine board enables fast memory accesses without necessitating the use of another VME slot. Other optional mezzanine boards provide parallel ports, a GPIB interface, a SCSI port, a real-time clock, and onboard DMA. Like the Force board, the GMSV07 also comes in a double-height Eurocard format.

Famous formats are available with VME Bus

As stated, boards based on 32-bit CPUs have sophisticated capabilities heretofore impossible to find on single-board computers. AT&T has optimized its version of Unix for the VME Bus, and to take advantage of this operating system, you have a choice of AT&T's WE 321SB single-board computer or Mizar's VME7125. Both boards are double-height Eurocards and are available with CPUs running at either 14 or 18 MHz.

The cards utilize AT&T's WE 32100 μP and Unix System V/VME Rel 3. This version of Unix includes specially restructured source code to ensure a tight fit with the VME Bus environment by simplifying the task of writing device drivers. Each board provides 1M bytes of onboard dynamic RAM and two RS-232C ports. For an 18-MHz version, the 321SB costs $4895, and the VME7125 costs $3995. You can opt for a WE 32106 coprocessor, a WE 32101 MMU, and 256k bytes of onboard EPROM.

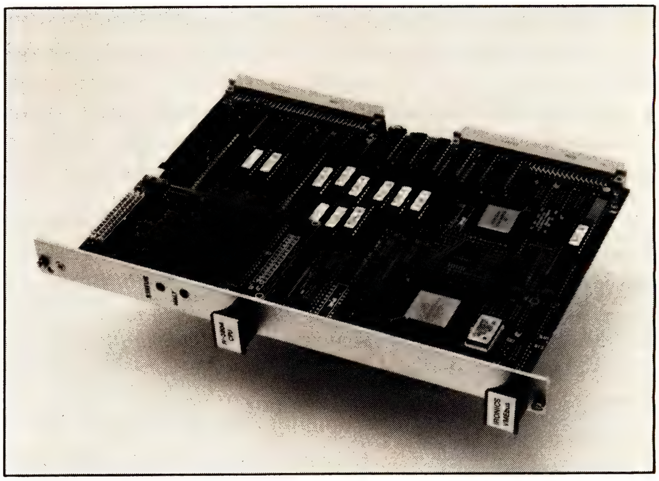
For those users who want DEC software compatibility, the DEC PDP-11 instruction set is available for the VME Bus. The VME-1120D board, available from Logical Design Group, and the VMEx J11 board, from Iskra VME Technologies, are designed around the 32-bit DEC J11 CPU operating at 15 MHz. Both boards run on the DEC RSX-11 operating system and are software compatible with PDP-11 computers ranging from the 11/03 to the 11/70.

Other bus structures are prominent, too

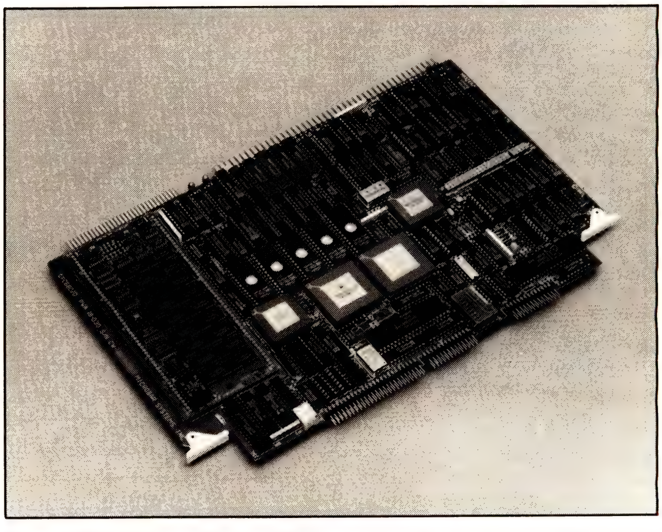
The power of 32-bit single-board computers isn't restricted to the VME Bus—it has carried over to other bus-structure environments as well. Microbar Systems offers 32-bit boards for Multibus I as well as Multibus II. These boards are optimized for multitasking applications using real-time or multiuser operating systems.

The Multibus I GPC68020 is based on the 68020 μP and has optional DMA, MMU, and FPU capabilities. It is configurable with 8M bytes of dual-ported dynamic RAM and 256k bytes of EPROM. Mailbox interrupts allow for interprocessor communications. An SBX connector provides standard I/O expansion capability for either 8- or 16-bit data transfers. An optional Hitachi DMA controller (68450) provides high-speed DMA-transfer capability to and from an SBX module, a parallel port, and two serial ports as well as from memory to memory. The board supports Unix V.2 for virtual-memory multiuser operation, VRTX 32, or PSOS. The MT68020A provides the same features for the Multibus II environment but includes an optional SCSI interface. The GPC68020 sells for $1712, and the MT68020A sells for $2373.

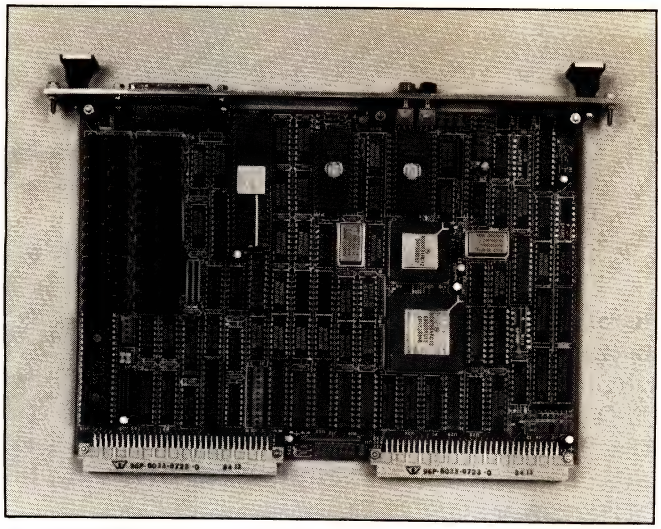
Thirty-two-bit microprocessors are also migrating to the low-end board market—G64 and G96 Bus cards, for instance. These buses are characterized by a compact single-height form factor and a pin-in-socket connector; boards for these buses function well in cost-sensitive



The IV-3204 multiprocessing engine from *Ironics takes advantage of the VME Bus's multimaster capabilities and contains a 68020 μP (16.7 or 20 MHz) and an optional 68851 PMMU or 68881 FPU.*



The GPC68020, a 32-bit-CPU board *sold by Microbar Systems, supports the Unix virtual-memory multiuser operating system for the Multibus I environment.*



***The MVME133A-20 board combines a 20-MHz 68020 CPU** with a 68881 FPU. The Motorola offering incorporates drivers for embedded-controller applications.*

Board costs vary according to clock speed and onboard memory—and of course options.

and harsh industrial environments. Although the G64 Bus is a nonmultiplexed 16-bit bus, you can achieve considerable processing speed by incorporating a 32-bit µP and a large amount of 32-bit-word memory on one card.

The GESMPU-20 from Gespac is such a board. It has a 12.5-MHz 68020 (16.7 MHz optional), 256k bytes of zero-wait-state RAM (512k bytes optional), and 512k bytes of EPROM. A 68881 coprocessor is also available. The board runs OS-9, a real-time, multitasking operating system, and costs $995.

The Monoputer from Microway is an example of a 32-bit-CPU board for two other low-end buses, the IBM PC/XT and the IBM PC/AT. It uses an Inmos T414 Transputer running at 20 MHz and has 2M bytes of high-speed RAM to provide parallel-processing capability. The board can access MS-DOS files and comes with an Occam compiler, a programming language that exploits the special properties of the Transputer. With a Transputer interface system, you can hook four or more Monoputers together inside one PC, and you can use a Monoputer either as a fast coprocessor or as a development tool to develop software for the Transputer. The board costs $1995.

Not all 32-bit-CPU board manufacturers have designed their products to interface with a bus. National

Manufacturers of 32-bit-CPU boards

For more information on the 32-bit-CPU boards included in this directory, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Alcyon Corp
5010 Shoreham Pl
San Diego, CA 92122
(619) 587-1155
Circle No 704

AT&T
Dept LT
555 Union Blvd
Allentown, PA 18103
(800) 372-2447
Circle No 705

Basu/Dage Precision Industries
Box 120A
Santa Clara, CA 95052
(408) 727-1932
Circle No 706

Charles River Data Systems
983 Concord St
Framingham, MA 01701
(617) 626-1000
Circle No 707

Cyclone Microsystems
25 Science Park
New Haven, CT 06511
(203) 786-5536
Circle No 708

Dual Systems Corp
2530 San Pablo Ave
Berkeley, CA 94702
(415) 549-3854
Circle No 709

DY-4 Systems Inc
1475 S Bascom Ave
Campbell, CA 95008
(408) 377-9822
Circle No 710

EMS Inc
1325 Capital Parkway
Carrollton, TX 75006
(214) 446-2900
Circle No 711

Force Computers Inc
727 University Ave
Los Gatos, CA 95030
(408) 354-3410
Circle No 712

In Europe:
Force Computers GmbH
Daimlerstrasse 9
D-8012 Ottobrunn, West Germany
(089) 600910
Circle No 713

General Micro Systems Inc
4740 Brooks St
Montclair, CA 91763
(714) 625-5475
Circle No 714

Gespac Inc
50A W Hoover Ave
Mesa, AZ 85202
(602) 962-5559
Circle No 715

GMX 1337
1337 W 37th Pl
Chicago, IL 60609
(312) 927-5510
Circle No 716

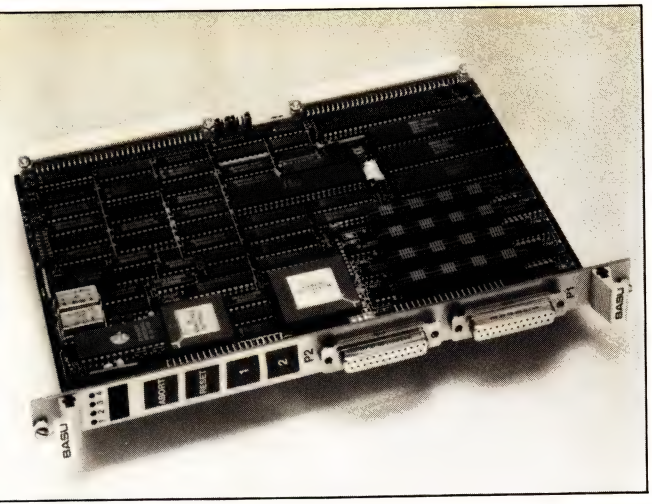
Hallock Systems Co Inc
271 N Main St
Herkimer, NY 13350
(315) 866-7125
Circle No 717

Heurikon Corp
3201 Latham Dr
Madison, WI 53713
(608) 271-8700
Circle No 718

Integrated Solutions
1140 Ringwood Ct
San Jose, CA 95131
(408) 943-1902
Circle No 719

Intel Corp
3065 Bowers Ave
Santa Clara, CA 95051
(408) 987-8080
Circle No 720

Ironics Inc
798 Cascadilla St
Ithaca, NY 14850
(607) 277-4060
Circle No 721



The CPU 20 board offers a SCSI interface *and an abundance of I/O capability for a multiprocessor environment. It is available from Basu/Dage Precision Industries.*

Semiconductor's approach, for example, is a departure from the traditional method of interconnecting boards through a backplane. Instead of the usual convention of bringing signal and power lines out to an edge connector and into a backplane bus, the company has designed its boards to stack vertically and directly connect through pin-in-socket 96-pin connectors. Similarly, stackable banana plugs implement the power connections. This direct-connect technique eliminates expensive backplanes and card cages.

The National Semiconductor ICM-332-2-15 CPU board is a 32-bit processing engine that fits this format. It uses an NS32332 CPU running at 15 MHz and features an NS32C201 timing-control unit, an NS32382 MMU, an NS32081 FPU, and an NS32202 interrupt-control unit. A 4M-byte onboard dynamic RAM and a 64k-byte ROM are standard. The size of the board is 9.18×11.02 in., and the price is $3645. Thanks to its four RS-232C ports, an 8-bit parallel port, a SCSI interface, and two special expansion buses (Flexibus for I/O and Mem32Bus for memory), the board is a powerful platform for the Unix environment. **EDN**

Article Interest Quotient (Circle One)
High 473 Medium 474 Low 475

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222 Sherwood Ave
Farmingdale, NY 11735
(516) 753-0400
Circle No 722

Logical Design Group Inc
541 Pylon Dr
Raleigh, NC 27606
(919) 834-8827
Circle No 723

Microbar Systems Inc
785 Lucerne Dr
Sunnyvale, CA 94086
(408) 720-9300
Circle No 724

Microproject Corp
4676 Admiralty Way, Suite 610
Marina del Rey, CA 90292
(213) 306-8000
Circle No 725

Microway Inc
Box 79
Kingston, MA 02364
(617) 746-7341
Circle No 726

Mizar Inc
20 Yorkton Ct
St Paul, MN 55117
(612) 224-8941
Circle No 727

Motorola Inc
Microcomputer Div
2900 S Diablo Way
Tempe, AZ 85036
(800) 556-1234
Circle No 728

National Semiconductor Dr
Box 58090
Santa Clara, CA 95052
(408) 721-5000
Circle No 729

Omnibyte Corp
245 W Roosevelt Rd
West Chicago, IL 60185
(312) 231-6880
Circle No 730

Pacific Microcomputers Inc
6730 Mesa Ridge Rd
San Diego, CA 92121
(619) 453-8649
Circle No 731

PEP Modular Computers Inc
600 N Bell Ave
Pittsburgh, PA 15106
(412) 279-6661
Circle No 732

Plessey Microsystems
1 Blue Hill Plaza
Pearl River, NY 10965
(914) 735-4661
Circle No 733

SBE Inc
2400 Bisso Lane
Concord, CA 94520
(415) 680-7722
Circle No 734

Synergy Microsystems Inc
179 Calle Magdalena
Encinitas, CA 92024
(619) 753-2191
Circle No 735

VME Specialists
558 Brewster Ave, Suite 1
Redwood City, CA 94063
(415) 364-3328
Circle No 736

REPRESENTATIVE 32-BIT-CPU BOARDS

VENDOR	MODEL	BUS COMPATIBILITY	32-BIT CPU	CLOCK SPEED (MHz)	ONBOARD RAM (BYTES)	AVAILABLE EPROM (BYTES)	I/O PORTS	DISK-DRIVE INTERFACES	DMA CHANNELS
ALCYON	A68VME-020	VME VSB	68020	16.7 (25 OPTIONAL)	1M (4M OPTIONAL)	256k	2 RS-232C	SCSI (OPTIONAL)	2 (FOR SCSI ONLY)
AT&T	WE 321SB	VME	WE 32100	14, 18	1M	256k	2 RS-232C	—	—
BASU/DAGE PRECISION INDUSTRIES	CPU 20	VME	68020	12.5, 16.7	1M	1M	2 RS-232C 8-BIT PARALLEL	SCSI	—
CHARLES RIVER DATA SYSTEMS	VCP-4000	VME	68020	16.7	8k (CACHE)	32k	3 RS-232C 1 RS-422/232C	—	1
	CP-20	VME	68020	16.7	8k (CACHE)	32k	4 RS-232C	—	1
CYCLONE MICROSYSTEMS	CY4110	VME	68020	12.5, 16.7, 20	2M (4M, 8M, & 16M OPTIONAL)	320k	4 RS-232C 1 CENTRONICS PARALLEL	SCSI, FLOPPY DISK	2
DUAL SYSTEMS	VMPU-32	VME	68020	16.7	1M	32k	—	—	—
	VMPU-4M	VME	68020	25	4M (AND 2k CACHE)	64k	—	—	—
DY-4 SYSTEMS	DVME-134	VME	68020	12.5 (16.7 OPTIONAL)	1M	64k	1 RS-232C	—	—
	DVME-137	VME VSB	68020	25	4M	256k	2 RS-232C	—	—
EMS	CPU-4SX/ 4QS	VME	68020	12.5 (16.7, 20 OPTIONAL)	1M (4M OPTIONAL)	128k	4 SERIAL (CPU-4QS ONLY)	SCSI (CPU-4SX ONLY)	—
FORCE COMPUTERS	CPU-386	VME	80386	16.0	2M (8M OPTIONAL)	256k	3 RS-232C	—	—
	CPU-24/25	VME	68020	16.7	512k (4M OPTIONAL)	64k	3 RS-232C	—	—
	CPU-20/21	VME	68020	12.5, 16.7, 20, 25	512k (4M OPTIONAL)	512k	3 RS-232C	—	—
GENERAL MICRO SYSTEMS	GMSV07	VME VSB	68020	16.7 (20, 25 OPTIONAL)	512k (1M OPTIONAL)	1M	RS-232C, RS-422/485, IEEE-488, PARALLEL (68230)	SCSI	4
GESPAC	GESMPU-20	G64	68020	12.5 (16.7 OPTIONAL)	256k	512k	—	—	—
GMX	MICRO-20	—	68020	12.5 (16.7, 20 OPTIONAL)	2M	256k	4 RS-232C, 3 8-BIT PARALLEL	SASI, FLOPPY DISK	—
HALLOCK SYSTEMS	PRO68 180/185/190	PC/XT PC/AT	68020	12.5 (180), 16.7 (185), 20 (190)	1M (4M OPTIONAL)	—	2 RS-232C, 32-BIT PARALLEL	—	3

CO-PROCESSOR	MEMORY MANAGEMENT UNIT	INTERRUPTS	POWER CONSUMPTION (W)	HIGH-LEVEL LANGUAGES	OPERATING SYSTEMS	PRICE	COMMENTS
68881	68851	7 VME, MAILBOX	30	C, FORTRAN 77, PASCAL	PSOS, REGULUS	$4500	BATTERY-BACKED CALENDAR/CLOCK; SYSTEM COUNTER (25-nSEC RESOLUTION)
WE 32106	WE 32101	7 VME, 8 ON BOARD	—	BASIC, COBOL 74, FORTRAN 77, PASCAL, C, ADA	UNIX SYSTEM V/VME 3.1, REGULUS, C EXECUTIVE, CSX	$3895 (14 MHz) $4895 (18 MHz)	3 PROGRAMMABLE COUNTER/TIMERS
68881	68851	7 VME, MAILBOX	—	BASIC, FORTRAN 77, PASCAL, C	UNIX V.2, PDOS, OS-9	$3290 (12.5 MHz) $4175 (16 MHz)	4-LEVEL BUS ARBITER; COUNTER/TIMER; 4-DIGIT DISPLAY
68881	MAP	256 HARDWARE VECTORS, 7 AUTOVECTORS	50	C, PASCAL, BASIC, COBOL, FORTRAN	UNIX SYSTEM V	$7900	BATTERY-PACKED CALENDAR/CLOCK; REAL-TIME CLOCK (1000 INTERRUPTS/SEC)
68881	MAP	256 HARDWARE VECTORS, 7 AUTOVECTORS	—	C, PASCAL, BASIC, COBOL, FORTRAN	UNIX SYSTEM V	$8000	BATTERY-BACKED CALENDAR/CLOCK; REAL-TIME CLOCK (1000 INTERRUPTS/SEC)
68881	68851	11 ON BOARD, 7 VME	43	C, FORTRAN, BASIC, PASCAL	PDOS	$5700 (12.5 MHz) $5900 (16.7 MHz) $6100 (20.0 MHz)	BOARD IS TRIPLE VME HEIGHT & WIDTH (367×280 mm); REAL-TIME CLOCK
68881	68KVMMB-851	MAILBOX, 7 VME	22	C, FORTRAN, COBOL, ASSEMBLER	UNIX 5.2.2, PSOS	$4450	REAL-TIME CLOCK (1000 INTERRUPTS/SEC)
68881	68851	MAILBOX, 7 VME	20	C, FORTRAN, COBOL, ASSEMBLER	UNIX 5.2.2, PSOS	$9990	REAL-TIME CLOCK (1000 INTERRUPTS/SEC)
68881	—	7 VME	30	C, ADA, PASCAL, ASM	VRTX 32, PSOS, HARMONY	$2660	
68881	—	7 VME	30	C, ADA, PASCAL, ASM	VRTX 32, PSOS, HARMONY	$5995	
68881	—	7 VME, MAILBOX	—	C, FORTRAN, PASCAL	PSOS, PDOS, EMSBUG	$1995	VME BUS ARBITER, TIMER/COUNTER
80387	(PART OF 80386)	8 ON BOARD, 6 VME (MASKABLE), 1 VME (NONMASKABLE)	30	C, PASCAL, FORTRAN 77	UNIX 4Q, UNIX 5.3, VRTX 32	$5775	MASTER ONLY; REAL-TIME CLOCK (100,000 INTERRUPTS/SEC)
68881 68851	68851	7 VME	52	C, PASCAL, FORTRAN 77	UNIX 5.3, UNIFLEX	$5695	2-BOARD SET; MASTER ONLY; REAL-TIME CLOCK (100,000 INTERRUPTS/SEC)
68881	—	7 VME, 6 ON BOARD	56	C, PASCAL, FORTRAN 77	UNIX 5.3, VRTX 32, PDOS, PSOS, UNIFLEX	$2895 TO $9995	2-BOARD SET; MASTER ONLY; REAL-TIME CLOCK (100,000 INTERRUPTS/SEC)
68881	—	7 VME, 3 MAILBOX	22	C, FORTH, PASCAL, BASIC, FORTRAN	VRTX 32, PDOS, PSOS, OS-9, UNIFLEX	$2395	MEZZANINE-BOARD EXPANSION FOR I/O AND MEMORY; REAL-TIME CLOCK
68881	—	5 VME, AUTOVECTORS, 1 NONMASKABLE	—	PASCAL, C, BASIC, ASSEMBLER	OS-9	$995	
68881 68882	—	7 ON BOARD	22	C, BASIC, PASCAL, FORTRAN 77	OS-9 UNIFLEX	$2565	REAL-TIME CLOCK (100,000 INTERRUPTS/SEC)
68881 68882	68851	256 HARDWARE	15	C, PASCAL, APL, PL/I, FORTRAN, RPG, BASIC, FORTH	MS-DOS, UNIX V 3.0, VRTX 32, PSOS, S1, MIRAGE, POLYFORTH	$2200 (180) $2800 (185) $3400 (190)	

Table continued on pg 154

REPRESENTATIVE 32-BIT-CPU BOARDS *(Continued)*

VENDOR	MODEL	BUS COMPATIBILITY	32-BIT CPU	CLOCK SPEED (MHz)	ONBOARD RAM (BYTES)	AVAILABLE EPROM (BYTES)	I/O PORTS	DISK-DRIVE INTERFACES	DMA CHANNELS
HEURIKON	HK68/V20	VME VSB	68020	12.5 (16.7, 20, 25 OPTIONAL)	256k (4M OPTIONAL)	128k	RS-232C	—	—
	HK68/V2F	VME	68020	12.5 (16.7, 20, 25 OPTIONAL)	256k (4M OPTIONAL)	128k	RS-232C	—	—
INTEGRATED SOLUTIONS	VME-68K20	VME HSMEM	68020	16.7 (25 OPTIONAL)	—	64k	2 RS-232C	—	—
INTEL	SBC 38621/22/24/28 SERIES	MULTIBUS I	80386	16	1M (21), 2M (22), 4M (24), 8M (28), ALL HAVE 64k CACHE	512k	RS-232C 8/16-BIT iSBX	—	—
	SBC 386116MI/2 4/8 SERIES	MULTIBUS II	80386	16	1M (M1), 2M (M2), 4M (M4), 8M (M8)	512k	RS-232C 8/16-BIT iSBX	—	4
IRONICS	IV-3201	VME VMX	68020	12.5 (16.7 OPTIONAL)	1M	64k	—	—	—
	IV-3204	VME VMX	68020	16.7 (20 OPTIONAL)	4M	64k	—	—	—
ISKRA	VMEx J11	VME	DJ11	15	512k	4k	RS-232C 8-BIT PARALLEL	—	—
LOGICAL DESIGN GROUP	VME-1120D VME-64	VME	DJ11	15	64k	8k	4 RS-232C/422 20 8-BIT PARALLEL (PROGRAMMABLE)	—	—
MICROBAR SYSTEMS	GPC68020	MULTIBUS I	68020	12.5 (16.7 OPTIONAL)	1M (8M OPTIONAL)	256k	2 RS-232C/422, 2 8-BIT PARALLEL, iSBX	—	4
	MT68020A	MULTIBUS II	68020	12.5 (16.7 OPTIONAL)	1M (4M OPTIONAL)	256k	2 RS-232C/422, 2 8-BIT PARALLEL, iSBX	SCSI	4
MICRO-PROJECT	INDUSTRIAL PROCESSOR MODULE	VME PROPRIETARY	68020	12.5 (16.7, 20, 24 OPTIONAL)	1M (4M OPTIONAL)	256k	2 RS-232C/422	SCSI (OPTIONAL)	—
MICROWAY	MONOPUTER	PC/XT PC/AT	T414	20	2M	—	4 SERIAL (TRANSPUTER COMPATIBLE)	—	—
MIZAR	MZ7120	VME	68020	16.7 (12.5 OPTIONAL)	1M	256k	—	—	—
	VME7125	VME	WE 32100	18 (14 OPTIONAL)	1M (4M OPTIONAL)	256k	2 RS-232C	—	—
MOTOROLA	MVME133A	VME	68020	20	1M	64k	RS-232C, RS-485/422, DEBUG PORT	—	—
	MVME134	VME	68020	16.7, 20	4M	64k	RS-232C	—	—
	MVME135/136	VME VSB	68020	16.7 (20 OPTIONAL)	1M	64k	4 RS-232C	—	—

CO-PROCESSOR	MEMORY MANAGEMENT UNIT	INTERRUPTS	POWER CONSUMPTION (W)	HIGH-LEVEL LANGUAGES	OPERATING SYSTEMS	PRICE	COMMENTS
68881	68851	7 VME, MAILBOX	46	C, PASCAL, FORTRAN, BASIC, ADA, COBOL	UNIX, VRTX 32, PSOS, OS-9	$2795	COUNTER/TIMER OPTIONAL; TIME-OF-DAY CLOCK
68881	68851	7 VME, MAILBOX	52	C, FORTRAN, PASCAL	VRTX 32, PSOS, OS-9	$1695	COUNTER/TIMER OPTIONAL; TIME-OF-DAY CLOCK
68881	DISCRETE LOGIC	7 VME	—	C, FORTRAN, PASCAL, LISP, ADA	UNIX 4.3, UNIX SYSTEM 5.3	$7900 (25 MHz) $2500 (16.7 MHz)	HSMEM BUS ARBITER
80387	80386 (ON CHIP)	16 LEVELS (ASYNC)	45	C, PASCAL, FORTRAN, COBOL, RPG, PLI, BASIC	iRMX286 (2), SYSTEM V/386, RMK386	$4800 (21) $5970 (22) $8310 (24) $12,990 (28)	3 REAL-TIME COUNTER/CLOCKS; 8M BYTES OF EXTENSION MEMORY
80387	80386 (ON CHIP)	255 BUS, 1 BROADCAST, 15 LOCAL	42	C, PASCAL, FORTRAN, COBOL, RPG, PLI, BASIC	iRMX286 (2), SYSTEM V/386, RMK386	$4800 (M1) $5970 (M2) $8310 (M4) $12,990 (M8)	3 REAL-TIME COUNTERS; 8M BYTES OF EXTENSION MEMORY; BUILT-IN SELF-TEST
68881	68851	7 VME	12.5	C, FORTRAN, ADA, PASCAL	UNIX V.2, PSOS, UNIFLEX	$2695	
68881	68851	7 VME	12.5	C, FORTRAN, ADA, PASCAL	UNIX V.2, PSOS, UNIFLEX	$4210	
—	DJ11	7 VME	15	FORTRAN, COBOL, BASIC PLUS 2	EXT. RSX-11M, DEC RSX-11	$2395	REAL-TIME CLOCK; 3 PROGRAMMABLE COUNTERS
—	DJ11	4 OF 7 VME	16	FORTRAN, COBOL, BASIC PLUS 2	DEC RSX-11	$2650	3 PROGRAMMABLE COUNTERS; 1-LEVEL ARBITER (OPTIONAL)
68881	68851	10 SOURCES, MAILBOX	30	C, ADA, FORTRAN	UNIX V.2, VRTX 32, PSOS	$1712	
68881	68851	10 SOURCES	35	C, ADA, FORTRAN	UNIX V.2, VRTX 32, PSOS	$2375	
68881	PROPRIETARY MAPPER	4 SOURCES	—	C, PASCAL, FORTRAN, MODULA	VRTX 32, PSOS, MTOS, OS-9, C EXECUTIVE, CSX	$2595	68681 PROGRAMMABLE COUNTER
—	T414	—	—	OCCAM 2, C, PASCAL, FORTRAN	MS-DOS	$1995	TRANSPUTER DEVELOPMENT TOOL
68881	—	7 VME	18	—	VRTX 32, PDOS, OS-9	$2195	4-MSEC HEART-BEAT TIMER
WE 32106	WE 32101	7 VME, MAILBOX	40	—	UNIX 3.0	$3995	5 PROGRAMMABLE COUNTERS; BATTERY-BACKED TIME-OF-DAY CLOCK
68881	—	7 VME	28	C, PASCAL	VRTX 32, PSOS, MTOS, RTUX, OS-9, VERSADOS	$3585	REAL-TIME CLOCK; 3-LEVEL ARBITER; 3 TIMERS
—	68851	7 VME	28	C, PASCAL, FORTRAN COBOL PROLOG	SYSTEM V/68, VERSADOS	$2250	3 TIMERS; 3-LEVEL ARBITER; REAL-TIME CLOCK
68881	68851	7 VME	28	C, PASCAL; FORTRAN COBOL PROLOG } 136 ONLY	VERSADOS; VRTX 32 PSOS MTOS RTUX OS-9 VXWORKS } 135 ONLY SYSTEM V/68 (136 ONLY)	$3934 (MVME135) $4256 (MVME136)	2 TIMER/COUNTERS; 3-LEVEL ARBITER

Table continued on pg 156

REPRESENTATIVE 32-BIT-CPU BOARDS *(Continued)*

VENDOR	MODEL	BUS COMPATIBILITY	32-BIT CPU	CLOCK SPEED (MHz)	ONBOARD RAM (BYTES)	AVAILABLE EPROM (BYTES)	I/O PORTS	DISK-DRIVE INTERFACES	DMA CHANNELS
NATIONAL SEMICONDUCTOR	ICM-332-2-15	—	NS32-332	15	4M	64k	4 RS-232C, 8-BIT PARALLEL, FLEXIBUS	SCSI	2
OMNIBYTE	OB/ACP-V022	VME	68020	12.5 (16.7 OPTIONAL)	2M	256k	2 RS-232C	—	—
PACIFIC MICROCOMPUTERS	PV682	VME VMX	68020	16.7	1M	1M	2 RS-232C/422/423	—	—
PEP MODULAR COMPUTERS	VMPM68KC	VME	68020	12.5, 16.7	1M (256-BYTE CACHE)	512k	2 RS-232C/422	—	—
PLESSEY MICROSYSTEMS	PME-68-21	VME VSB	68020	16.7 (20, 25 OPTIONAL)	2M (1k CACHE)	64k	2 RS-232C	—	—
	PME-68-22	VME	68020	20	2M (8M OPTIONAL)	64k	2 RS-232C	SCSI	—
	PME-68-23	VME	68020	16.7 (12.5, 20 OPTIONAL)	2M (16M OPTIONAL)	512k	3 RS-232C, 8-BIT PARALLEL, 24-BIT PARALLEL	FLOPPY DISK	—
SBE	MPU-20-600	MULTIBUS I	68020	16.7 (12.5 OPTIONAL)	1M (8M OPTIONAL)	256k	2 RS-232C, 24-BIT PARALLEL, 2 iSBX	—	—
SYNERGY MICROSYSTEMS	SM20F	MULTIBUS I	68020	16.7 (12.5, 20 OPTIONAL)	1M (4M OPTIONAL)	4M	2 RS-422/423	SCSI	4 (OPTIONAL)
VME SPECIALISTS	SBC3	VME	68020	12.5 (16.7, 20 OPTIONAL)	256k	256k	2 RS-232C	—	—

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CO-PROCESSOR	MEMORY MANAGEMENT UNIT	INTERRUPTS	POWER CONSUMPTION (W)	HIGH-LEVEL LANGUAGES	OPERATING SYSTEMS	PRICE	COMMENTS
NS32081	NS32382	16 HARDWARE	33	C, FORTRAN, PASCAL, COBOL, BASIC	UNIX V.3	$3645	S8274 REAL-TIME CLOCK (10 INTERRUPTS/SEC)
68881 68882	—	MAILBOX	19	FORTRAN, C, PASCAL	VERSABUG	$2795	
68881	PACIFIC's MMU	7 VME, MAILBOX	43	FORTRAN, C, PASCAL	PACIFIX V.2	$4360	3 PROGRAMMABLE TIMER/COUNTERS; REAL-TIME CLOCK
68881	—	7 VME	13	FORTRAN, C, PASCAL	OS-9/68K	$2600 (12.5 MHz) $3500 (16.7 MHz)	REAL-TIME CLOCK; 1-LEVEL BUS ARBITER
68881	—	7 VME	38	FORTRAN, C	PLUM	$1850	4-LEVEL ARBITER
68881	68851	7 VME, MAILBOX	23	C, FORTRAN, PASCAL	UNIX 5.2, VERSADOS, OS-9, PDOS	$4350	REAL-TIME CLOCK; 4-LEVEL ARBITER
68881	—	7 VME, MAILBOX	28	C, FORTRAN, PASCAL	VERSADOS, OS-9, PDOS, PLUM	$5465	REAL-TIME CLOCK; 4-LEVEL ARBITER
68881	SBE's MMU (OPTIONAL)	7 MULTIBUS, MAILBOX	25	C, PASCAL, FORTRAN	REGULUS, UNIX SYSTEM V (2.0)	$2995	24-BIT TIMER
68881 (DAUGHTER BOARD)	SM20F MMU	7 MAILBOXES	30	FORTH, C, FORTRAN	UNIX V.2, HUNTER, VRTX 32, SYNERG X	$3480 (100)	5 PROGRAMMABLE TIMERS, REAL-TIME CLOCK
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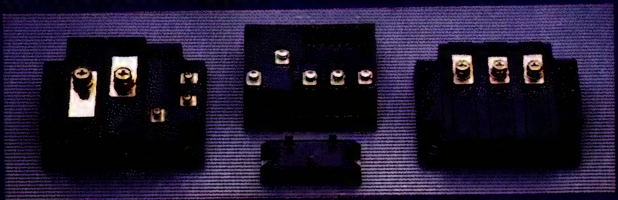

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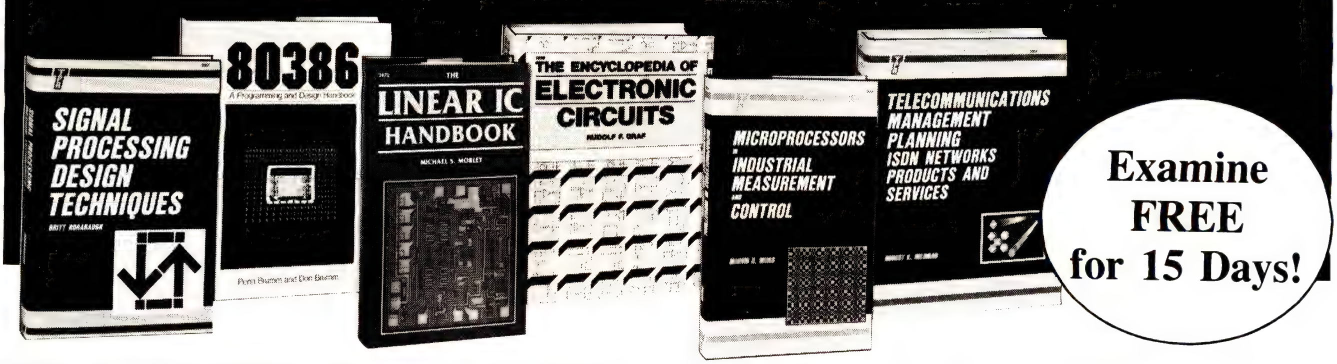
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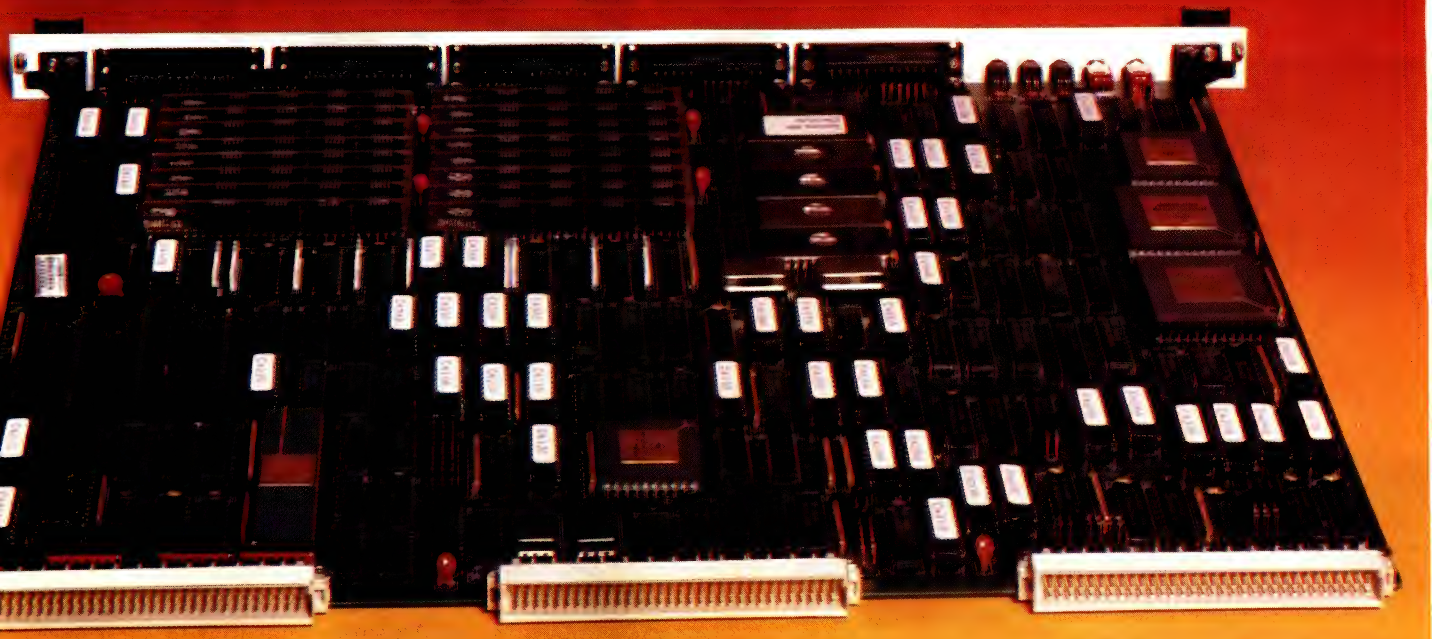

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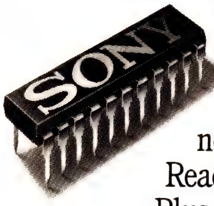

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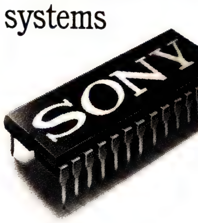

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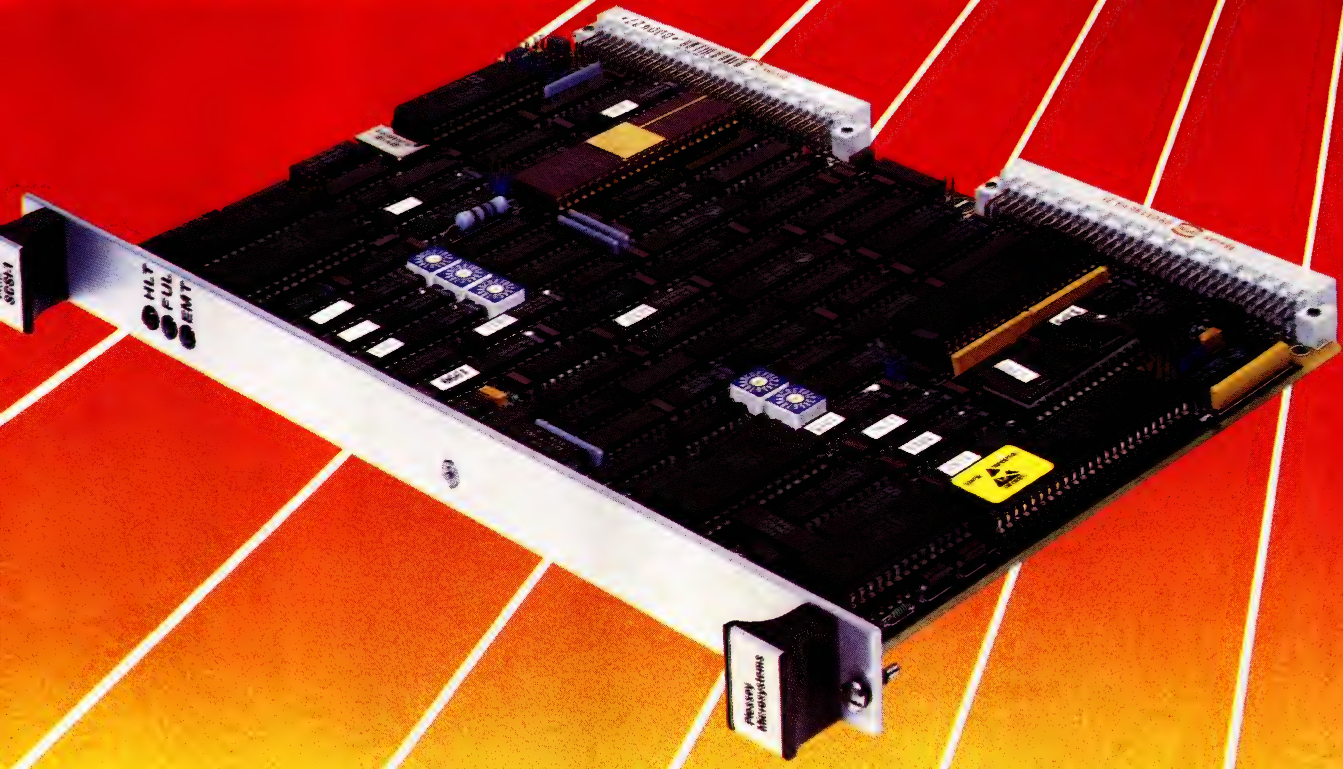

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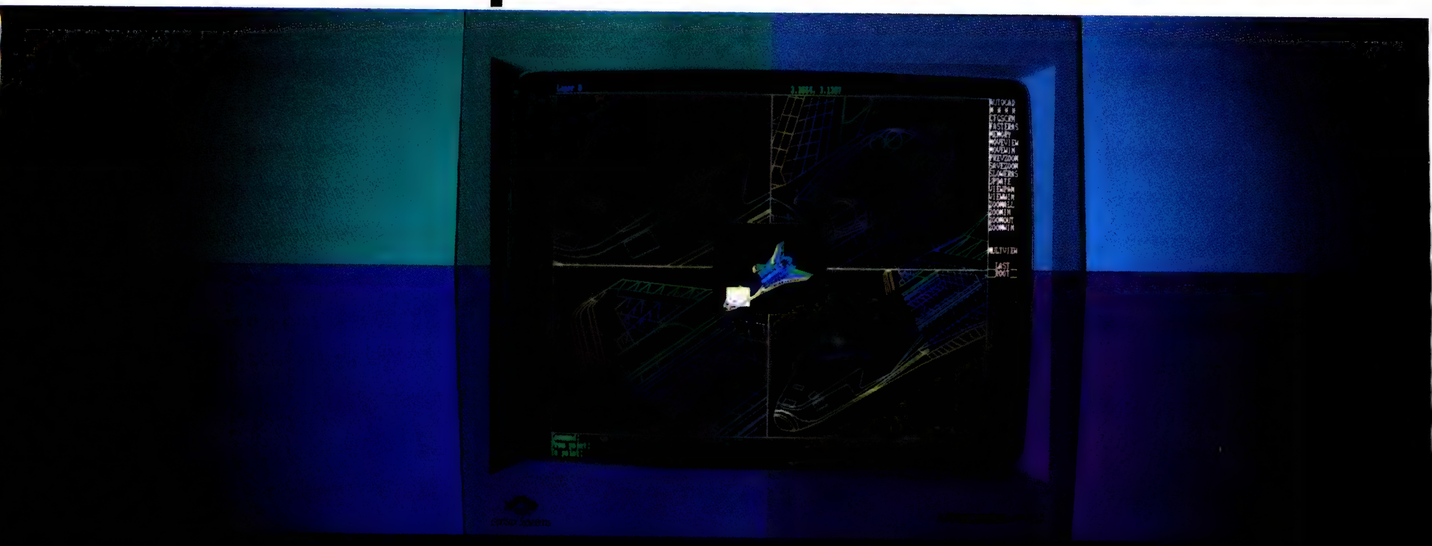

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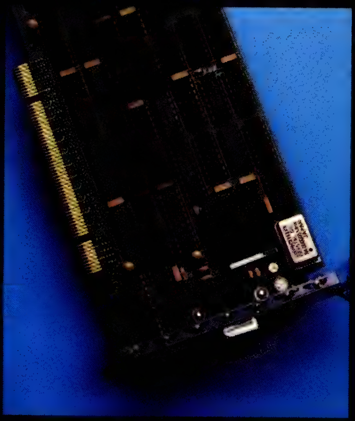

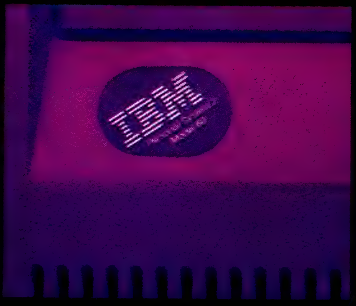

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Partitioning adapts large state machines to PLDs

Registered PLDs are ideal for implementing state-machine designs, but a large state machine can require more product terms per register than even the biggest EPLDs offer. However, a simple partitioning technique may let you split your state machine into two or more smaller state machines, which may then fit into a single PLD.

Clive McCarthy, *Altera Corp*

Even though you can now obtain a PLD with as many as 480 product terms in the Altera EP1800 device, a large state machine can easily exhaust any PLD's finite number of product terms per register when you are realizing the logic equations for your state machine's next-state decoder. A systematic method for breaking large, complex state machines into two or more smaller and simpler—but cross-linked—state machines can then often prove useful for implementing your design in a PLD.

If you partition your state machine, you can reduce the demand for next-state product terms, but you must increase the state variables at the same time. The resulting design usually requires a larger number of state registers but makes fewer demands on the PLD's AND-OR matrix, which feeds the registers. Though your partitioned design could conceivably require more state registers than are available in a given PLD, splitting a state machine usually results in smaller equations for each register.

Technique not universally applicable

Be aware, however, that this technique is not universally applicable. The method does not always reduce the size of the next-state equations—especially for a smaller or a strongly connected machine (a counter is an extreme example of a strongly connected state machine). The results depend a great deal on how you split the state machine up, on how complex the equations are, and on how you make your state assignments.

Often you have to try many different splits and state assignments before you find a sufficiently good implementation. Doing a number of implementations manually is a tedious, error-prone task. Fortunately some PLD compilers, such as Altera's A+Plus, allow you to enter your design specification directly in state-machine format rather than in truth tables or Boolean equations.

This flexibility makes design iterations considerably easier because you can simply edit your design-specification file and then use the compiler. The compiler quickly does the dog work of deriving and minimizing your design's Boolean equations and of calculating how many product terms that particular design iteration requires.

About a third of all small-scale registered PLDs get used as state machines.

But whether you use PLD design software or do the job manually, the principles of partitioning state machines are the same. Before delving into a complex, actual design example, consider the hypothetical example in **Fig 1a**. It shows a part of a state-transition diagram (formally called a directed graph and informally a bubble chart) describing a complex state machine. In accordance with standard practice for bubble charts, the states are annotated as S_1, S_2 . . . S_6. Each state is a logical product, a unique combination of the states of the individual state variables, V_1 to V_N. The PLD's registers store the present state of the state machine.

For example, S_3 could represent the combination $V_1{*}/V_2{*}/V_3{*}/V_4$, where "*" is the logical product (the AND function) and "/" is logical inversion (the NOT function).

Directional arrows marked with the symbolic labels E_1 to E_5 connect the states. These arrows show allowable transitions to and from the states. The arrows' labels represent events that cause the state machine to progress from one state to the next. Each label represents a logic equation. (These equations should normally be functions of inputs to the state machine.) **Fig 1** thus shows how the state machine can respond t external events in a predictable sequence.

Note that the diagram does not completely follow standard practice in that it does not show what response the state machine makes to the inputs that cause

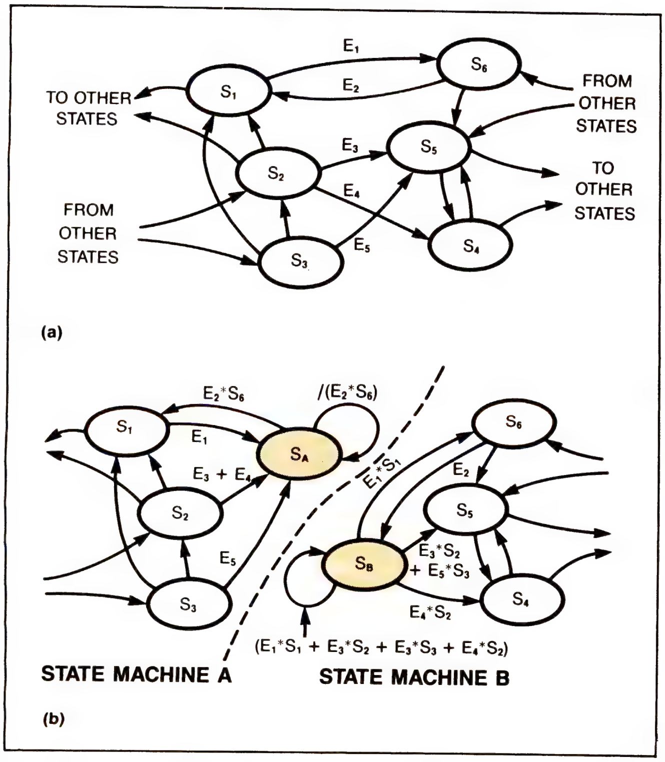

*Fig 1—**The hypothetical state machine in (a)** gets partitioned into two linked state machines in **(b)** using the rules in the **box**, "Rules for partitioning state machines."*

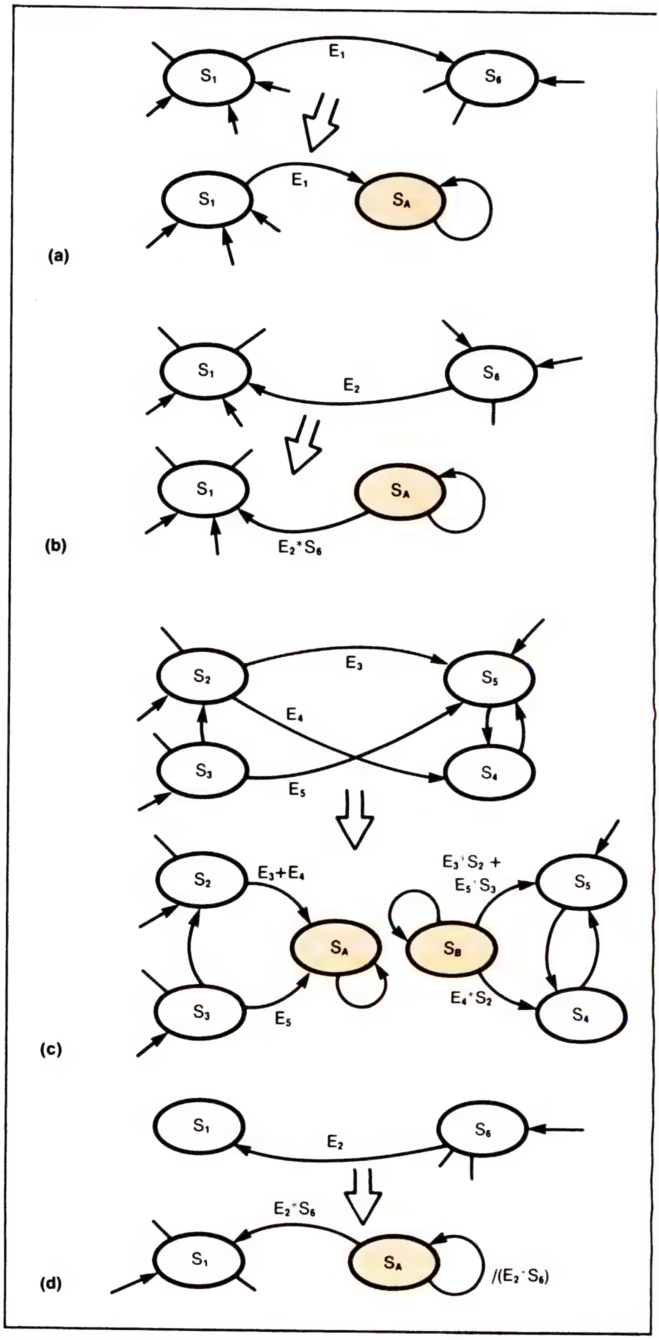

*Fig 2—**The partial state diagrams (a) through (d)** show a transistion-by-transition decomposition of the state machine in **Fig 1** according to the rules in the **box**.*

t to make transitions. Although the state machine's equired outputs can affect how you assign your state ariables, outputs are not germane to the problem of artitioning and therefore don't appear in the diagram.

plit the machine

Conceptually, the splitting process is fairly simple. irst, draw a line that crosses all transitions going etween the two halves of the state machine you want o separate. For each half of the state machine, reposiion the transitions into the other half with transitions o a new state, called an idle state.

The idea is that while things are happening in one alf of the state machine, the other half sits in its idle tate. When the sequence of events occurs that should ave caused one of the connecting transitions of the riginal state machine to be transversed, then the urrently active half of the state machine goes into its dle state while the currently idle half leaves its idle tate and goes to whatever state is appropriate for that vent.

Fig 1b shows **Fig 1a**'s state machine divided in two. The split puts states S_1, S_2, S_3 (and all undepicted states to the left of these states) in a separate machine from the remainder of the diagram. Although the diagram doesn't show all the states and transitions of the entire state machine, E_1 to E_5 *are* all transitions between these two halves of the diagram.

Idle state fills in

States S_A and S_B are the idle states for each half. Several features of the divided state machine merit close examination. Note that all transitions that would have resulted in crossing from one half to the other now go to the idle states. Further, transitions leaving the idle states depend not only on inputs, but on both the original transition equation (E_1, E_2, and so on) and on the current state of the opposing half of the state machine. Lastly, the transitions represented by the arrows that loop back keep the state machines in their idle states and are simply the logical inverse of all

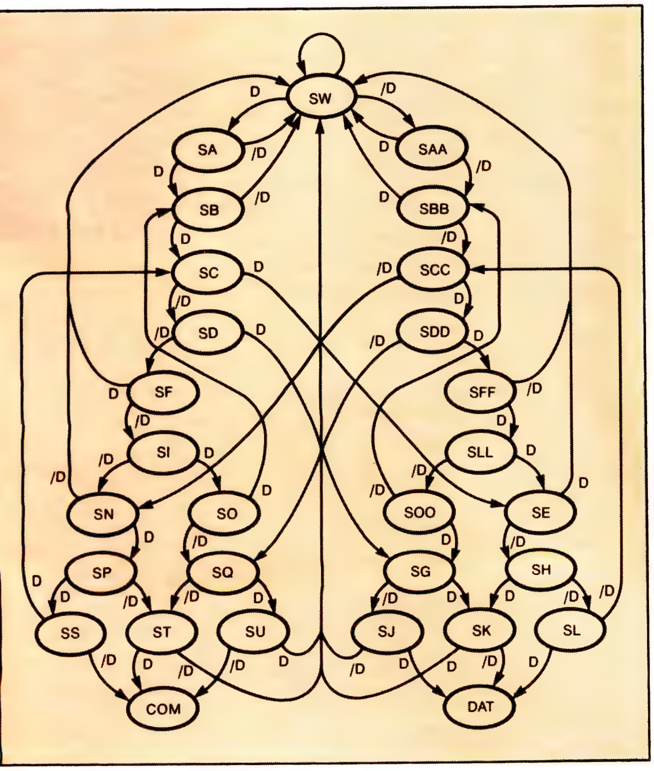

Fig 3—This real-world example is a state machine that converts a Manchester-encoded data stream into a data stream suitable for a conventional UART. The design as it stands doesn't fit in even the largest available PLD—an EPLD.

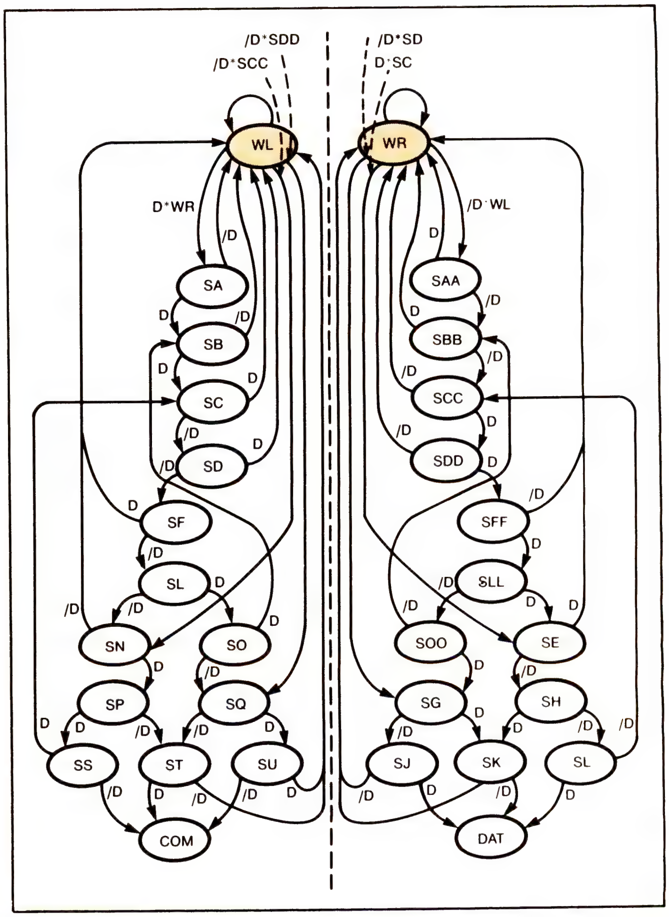

***Fig 4—Splitting Fig 3's state diagram down** the middle results in a design that fits an available EPLD.*

A large state machine can easily exhaust any PLD's finite number of product terms per register.

transitions that cause an exit from each idle state.

Fig 2 shows a transistion-by-transition breakdown of the decomposition of **Fig 1a's** state machine into the two state machines in **Fig 1b** (see **box,** "Rules for partitioning state machines").

Design example

Fig 3 is a real-world example. The state machine converts a Manchester-encoded serial-data stream into a standard UART-compatible serial-data stream. The state machine also extracts data about the nature of the information being received. This particular design, after A+Plus minimization, resulted in five equations that each have from eight to 13 product terms **(Ref 1).** With these product-term requirements this design would not fit into any of the available EPLDs. Because it's so symmetrical, this design is clearly a candidate for partitioning right down the middle.

The state diagram in **Fig 4** shows one way to partition the design. The state previously marked SW has been split into idle states WL and WR for the left and right halves of the resulting state machines. This partitioning was possible because the state SW was a hold state in the original design (the conditions for holding now get ORed together). When both of the partitioned machine halves are in their idle states (WL and WR) at the same time, you have the equivalent condition of the original machine sitting in state SW.

Rules for partitioning

You should bear in mind some rules for transforming transitions when partitioning a state machine:

- Transitions leading into an idle state keep the same equation as the corresponding transition from the original machine.
- Transitions leading out of an idle state also have the equation from the corresponding transition in the original machine with one addition: You logically AND the equation with the state of the machine half from which the transition originally came.
- You can replace multiple transitions that have the same source and destination states by a single transition with an equation that is the logical OR of the original equations.
- The idle states require a new "hold" transition. This new hold transition's equation is the logical inverse of all equations for transitions leaving that state logically ORed together.

If you compare the partitioned machines with the original machine, you get:

	ORIGINAL	PARTITIONED
STATES	29	15+15=30
STATE VARIABLES	5	4+4=8
PRODUCT TERMS	50	50
PEAK PRODUCT TERMS PER REGISTER	13	7

EDN

Reference

1. For full details of the design-entry file, contact Altera Corp, 3525 Monroe St, Santa Clara, CA 95051. Phone (408) 984-2800 and ask for application note *AB 18.*

Author's biography

Clive McCarthy is vice president of software engineering for Altera Corp in Santa Clara, CA. He was formerly director of applications for Altera. He is now responsible for all CAE software for his company's line of programmable logic devices. Previously, he worked for Fairchild, Northern Telecom, and Texas Instruments. He obtained a BSc (Honours) in electronics from Salford University in the UK.

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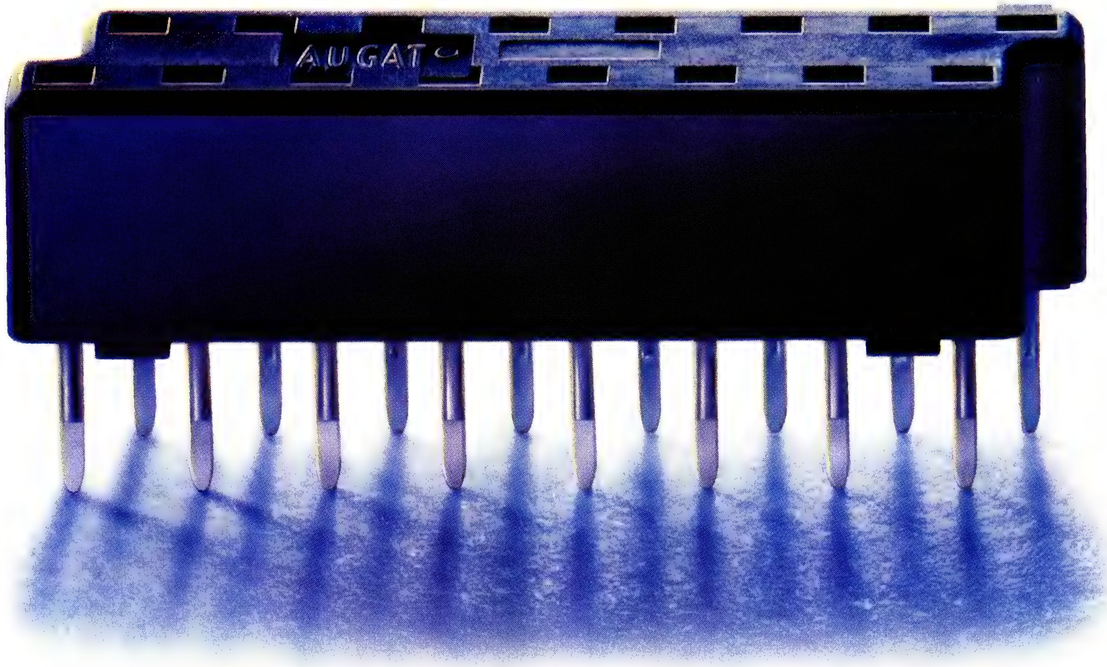

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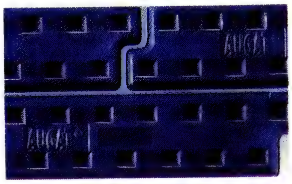

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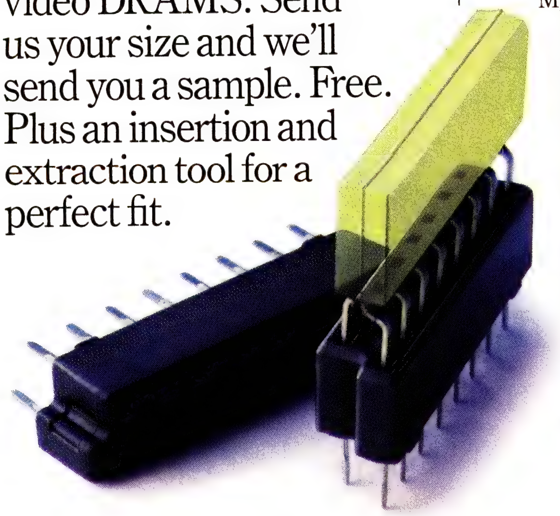

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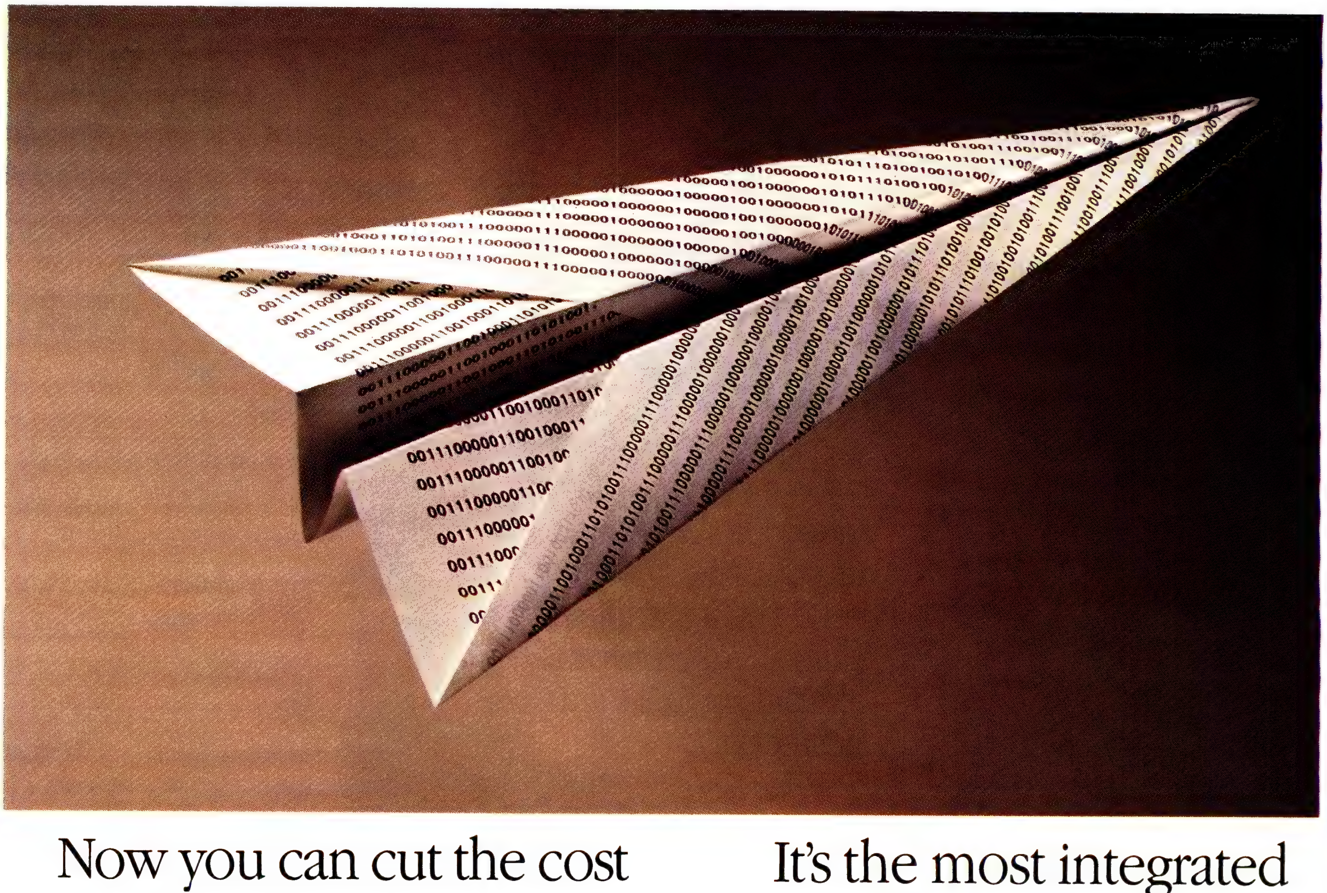

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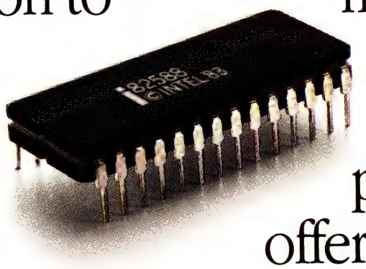

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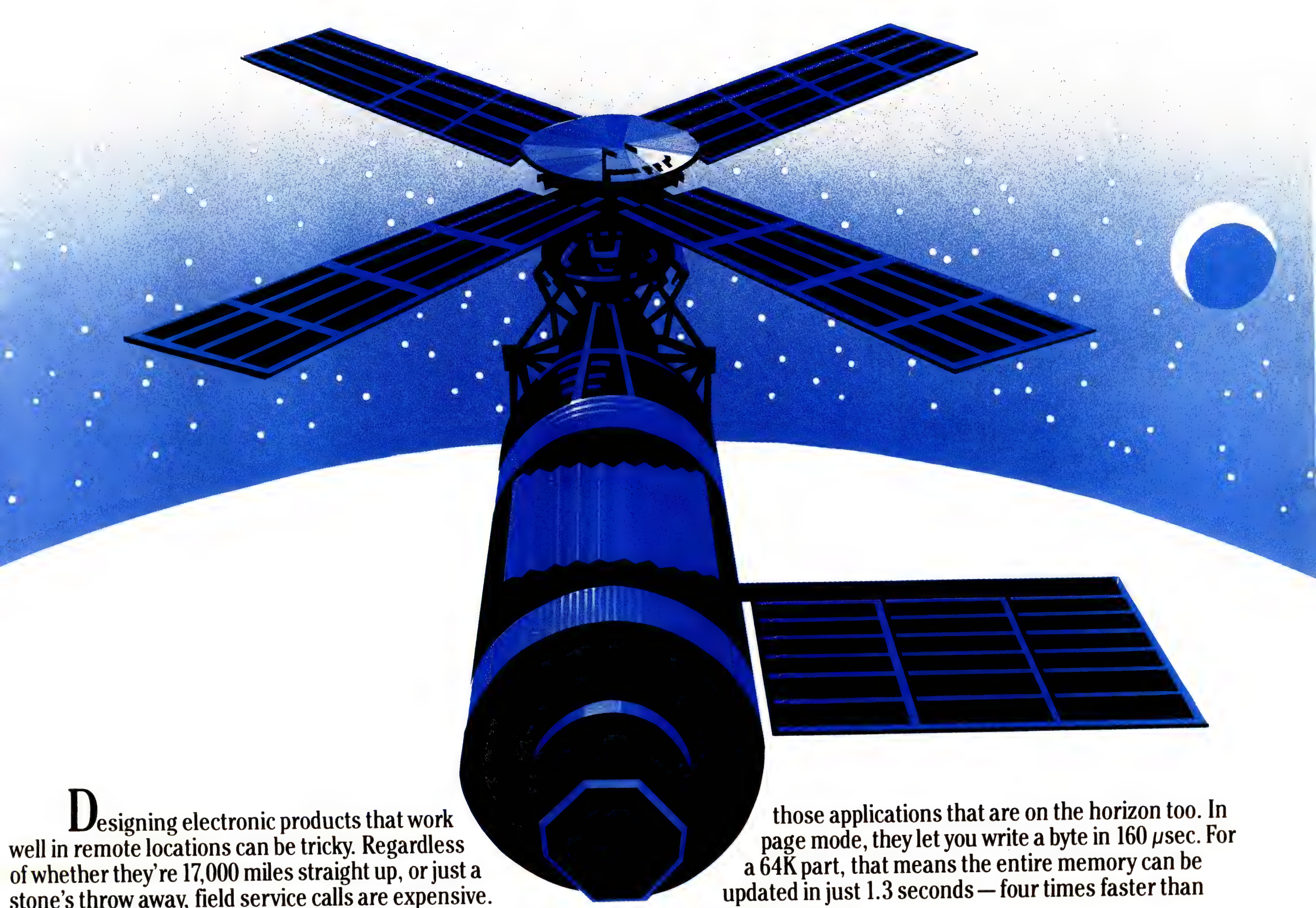

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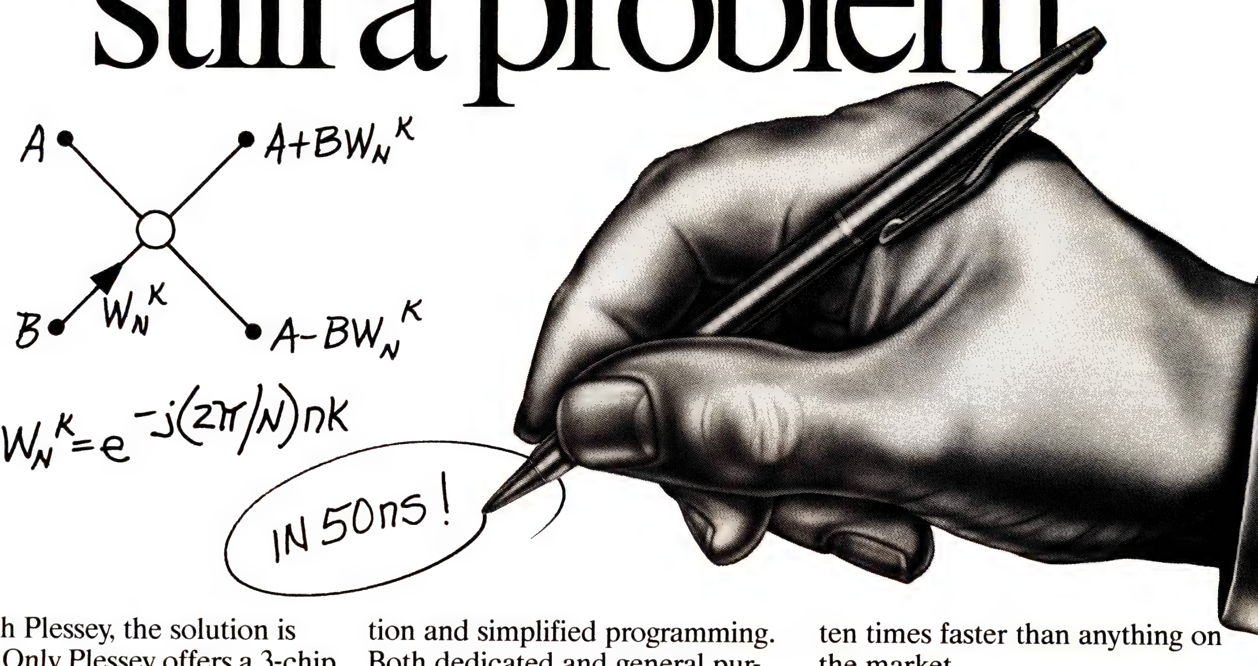

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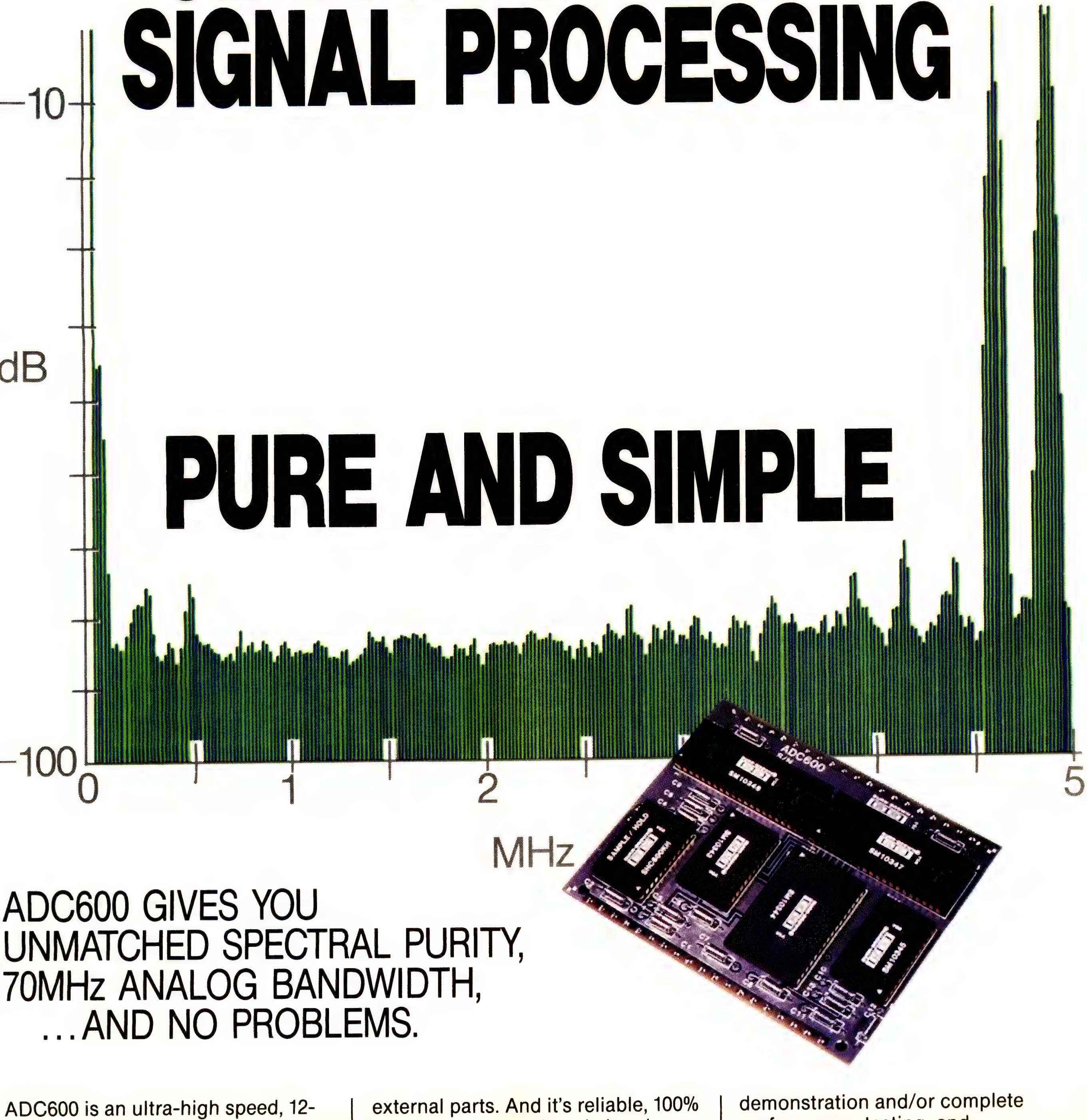

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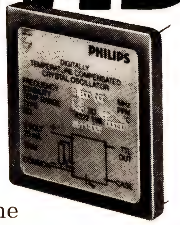

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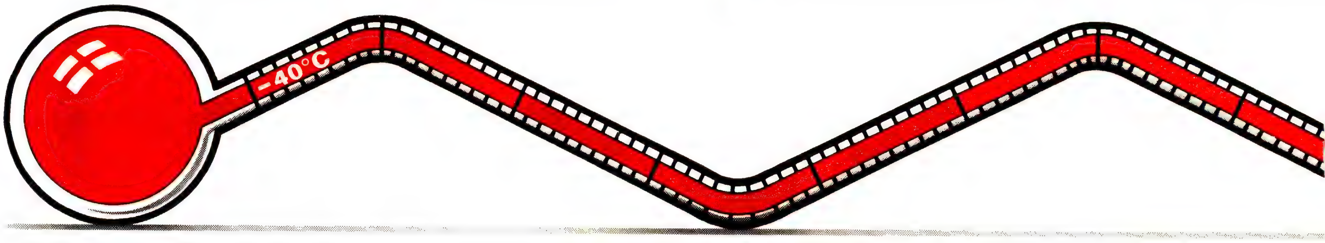

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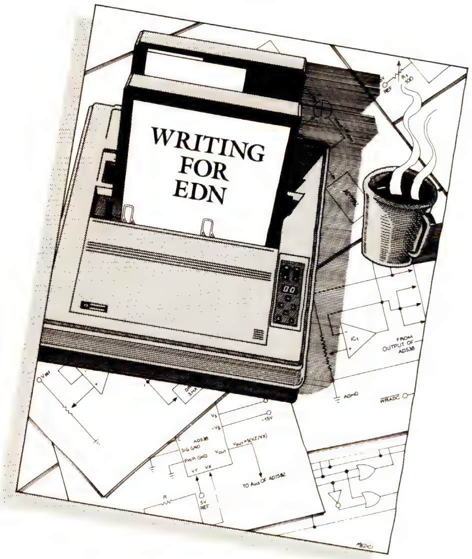

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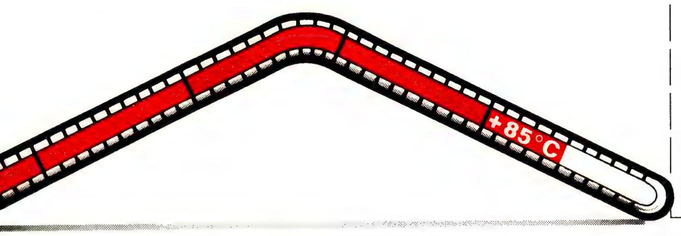

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CIRCLE NO 205

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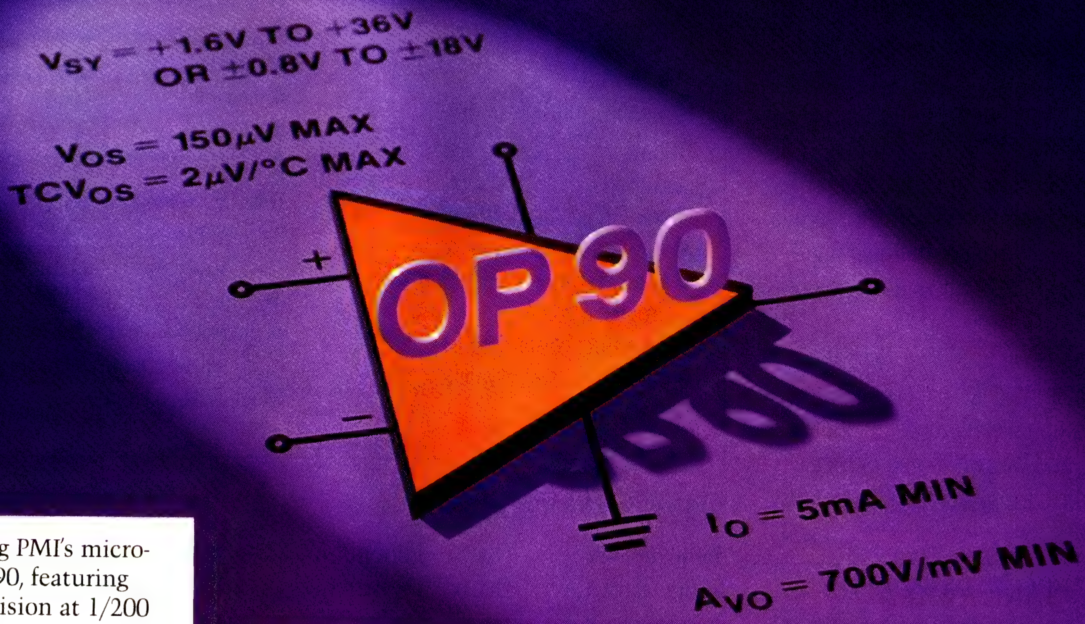

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Active feedback improves amplifier phase accuracy

Using matched op amps and active feedback, you can minimize the phase error and so extend the bandwidth of an amplifier by more than an order of magnitude. This technique is cheaper than using wideband amplifiers and less sensitive to the temperature-related drift specifications of passive components.

James Wong, *Precision Monolithics Inc*

In applications such as sonar and image-processing systems, the phase relationship between two or more signals reveals essential information. These systems require accurate phase response in their amplifier circuitry to minimize measurement errors. In such cases, active feedback can often serve much better than other approaches. A typical op amp is insufficient in this situation because it introduces significant phase shift long before it reaches its −3-dB frequency. The consequent phase error reduces the effective bandwidth of an op amp to something significantly less than the −3-dB point.

You can use a wideband amplifier to overcome this phase-error problem. If the wideband amplifier operates with a −3-dB bandwidth that is much higher than that of the signal that you intend to amplify, then the phase error at your signal's frequency decreases proportionately. The wideband amplifier's greater expense is the main drawback to this approach.

If you cascade two or three amplifiers, each of which has its gain reduced to share the overall gain of the composite amplifier, the gain reduction at each stage of the amplifier increases the −3-dB bandwidth of each stage of the amplifier. Consequently, the overall bandwidth for a given phase accuracy is increased, but you pay for this improvement with increasingly higher costs and noise levels.

Another, less expensive way to solve the phase-error problem is to introduce extra circuitry in the amplifier's feedback loop, which provides frequency compensation. You can use an RC circuit to create a zero in the feedback loop that cancels the amplifier's pole. This cancellation improves the phase response markedly by lessening the amplifier's phase-response roll-off. The chief disadvantage of the RC technique is that it requires extensive tuning to match the zero with the pole. Furthermore, the different temperature coefficients of the RC components cause the zero to drift. And when the zero drifts, it no longer cancels the pole, and phase error becomes a problem once again.

Placing an op-amp circuit in the feedback stage of the amplifier creates the active feedback that can overcome the temperature drift of the RC networks. It is also a thriftier approach than using a wideband amplifier. You

A typical op amp introduces significant phase shift long before it reaches its −3-dB frequency.

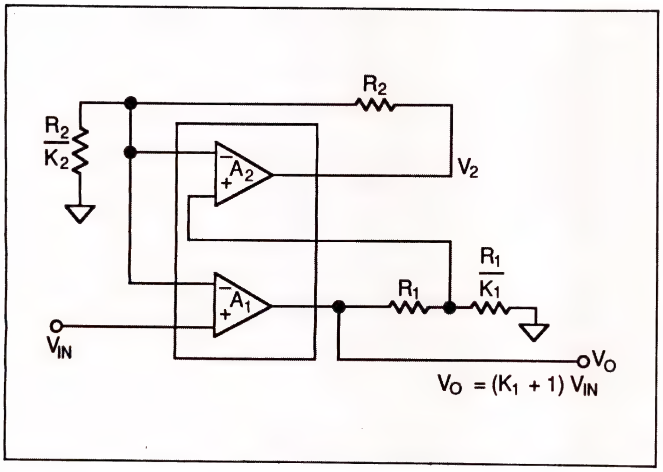

Fig 1—Second-order compensation, *as provided by the op amp in the feedback path of this circuit, extends the effective bandwith of an amplifier substantially.*

TABLE 1—AC-ERROR COMPARISON

FREQUENCY	SINGLE-STAGE CONVENTIONAL PHASE (DEGREE)	CASCADED (TWO-STAGE) PHASE (DEGREE)	SECOND-ORDER COMPENSATION PHASE (DEGREE)
5 kHZ	−0.57	−0.36	0
10 kHZ	−1.15	−0.72	−0.0005
50 kHZ	−5.7	−3.62	−0.06
100 kHZ	−11.3	−7.21	−0.46
500 kHZ	−45.0	−45.0	−45.0

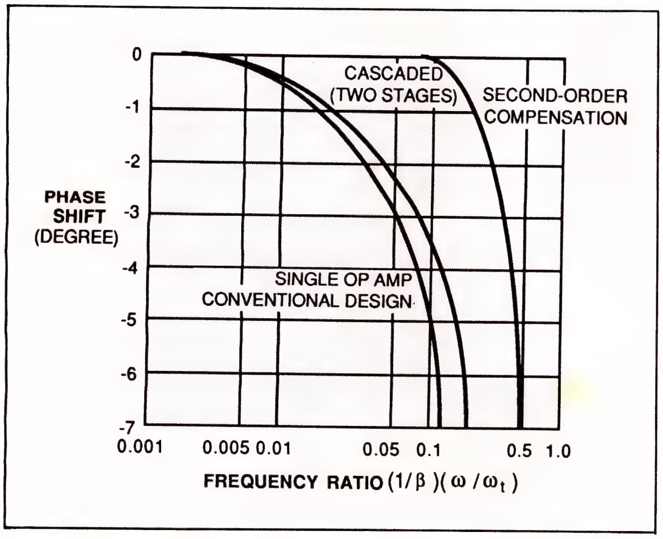

Fig 2—Phase shift for single-op-amp, *cascaded-op-amp, and second-order-compensation designs is charted here. Note the significant improvement brought about by second-order compensation.*

must make sure, however, that the op amps are very closely matched. Monolithically matched dual or quad op amps can provide the frequency-matching characteristics (to within 1 to 2%) necessary for the success of the active-feedback approach. This close matching is necessary across the full temperature range of your application. It's easier to achieve in an integrated dual or quad op amp than it is in discrete resistors and capacitors.

Fig 1 shows a basic active-feedback circuit. It requires an op amp and two external resistors to achieve phase-error cancellation. In the circuit, op amp A_1 provides the forward gain of the composite amplifier. Resistors R_1 and R_1/K_1 determine the closed loop gain A_V»$1+K_1$. Amplifier A_2 provides active feedback to op amp A_1. The ratio of resistors R_2 and R_2/K_2 determines the amount of phase-error compensation and has no effect on the forward gain of the composite amplifier. You obtain optimum error cancellation when $K_1=K_2$.

In terms of the complex frequency response, the error terms for the circuit are given by

$$\text{magnitude error} \cong \left(\frac{\omega}{B\,\omega_T}\right)^2$$

$$\text{phase error} \cong -\left(\frac{\omega}{B\,\omega_T}\right)^3.$$

These equations let you compare the phase error associated with a single amplifier with that associated with the 2-op-amp, active-feedback approach. They arise from a complete analysis of the basic circuit and its derivatives (see **box,** "Analyzing compensation techniques").

Dominant poles occur at 500 kHz

Table 1 tabulates the phase error and magnitude error for an amplifier with a gain of 10. The comparison assumes that the op amp's unity-gain bandwidth is 5 MHz. As you can see in the **table,** the dominant poles of all three amplifiers occur at 500 kHz, where the phase shift for each technique is −45°. Clearly, the compensation techniques do not extend the bandwidth of the op amp itself. Rather, these second-order compensation techniques reduce the phase error at lower frequencies by adding an equal but opposite phase shift in the amplifier feedback loop.

If you must limit phase error to less than half a degree, the second-order compensation technique increases the effective bandwidth of your amplifier from about 5 kHz to more than 100 kHz. If you need to limit phase entirely, the second-order compensation limits phase error virtually to zero at frequencies to 50 kHz; a single-stage amplifier would be limited to well below 500 Hz.

The magnitude and phase responses are plotted in **Figs 2** and **3**, respectively. The single op-amp response serves as a basis for comparison. The maximum scale of 1.0 represents the −45° phase-shift frequency. **Fig 2** shows that the cascaded 2-stage amplifier offers only a slight improvement in bandwidth, and that the second-order compensation method offers a significant improvement in effective bandwidth.

The tradeoffs are minor

The tradeoffs associated with the second-order feedback technique are minimal. **Fig 3** illustrates the appreciable gain peaking incurred, but the circuit typically peaks at about 3 dB at the −45° phase frequency, well outside the useful range. Within the frequency range where phase shift is negligible, the gain error is also insignificant. In **Fig 3,** for example, at ⅒ of the corner frequency, gain error is only 0.1 dB, about 1.2%.

In executing the second-order compensation design, it's extremely important to use op amps with frequency responses matched to within 1 to 2%. Op amps packaged separately can have mismatches as high as 10 to 20%, and high levels of mismatching cause either over- or undercompensation. Overcompensation creates excessive phase peaking, and undercompensation causes early phase roll-off.

Theoretically, second-order compensation works for any closed-loop gain. In practice though, at low gains, within the 1-to-5 range, the circuit may become unstable due to phase-margin degradation introduced by the active feedback. As a rule of thumb, you should work with a gain of 10 or greater. The match between theoretical and actual performance improves as the gain of the circuit is increased.

A circuit using the second-order compensation is illustrated in **Fig 4**. The op amp used in this example is an OP-470, which is unity-gain stable and provides a 6-MHz unity-gain bandwidth. It's a quad op amp that offers a 1% match in ac characteristics between the four op amps on the chip. The circuit provides a gain of 10 for the amplifier.

The actual phase response of the circuit was measured using a network analyzer and is compared with a single-stage amplifier in **Fig 5.** The measurement confirms that the phase shifts of the second-order-compensated design and the single-stage design converge at

Text continued on pg 185

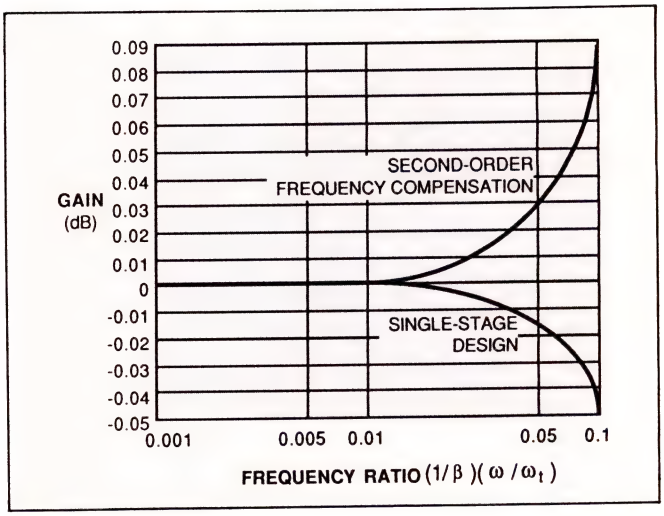

*Fig 3—**Second-order compensation** does carry the penalty of gain peaking, but this doesn't become significant until close to the corner frequency.*

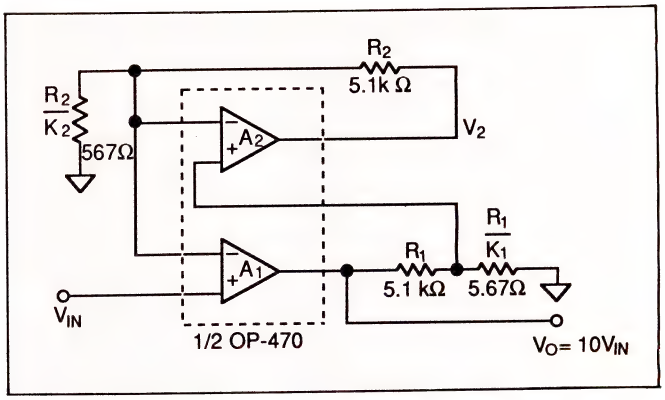

*Fig 4—**This amplifier uses** the second-order compensation technique and has a gain of 10.*

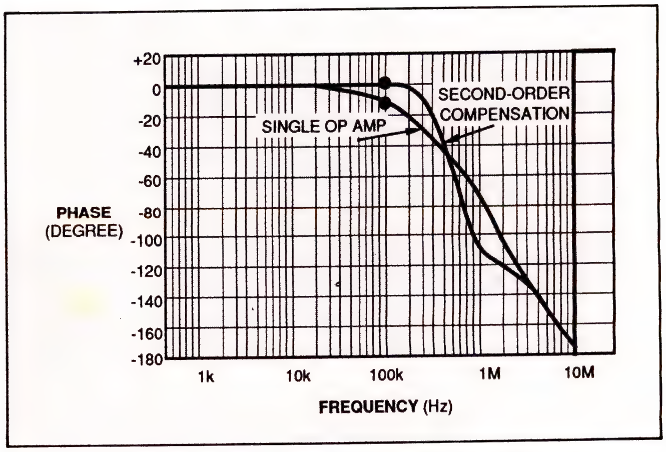

*Fig 5—**The phase response of Fig 4's circuit** illustrates the improved flatness of response that can be attributed to second-order compensation.*

Analyzing compensation techniques

A single-stage amplifier without any band-limiting circuit, as shown in **Fig A**, rolls off according to the closed-loop gain of the circuit and the amplifier's own natural frequency response. You can approximate the amplifier's open-loop frequency response in this way:

$$\text{open-loop gain } A(s) \cong \frac{A_O}{1+\frac{A_O}{\omega_T}s},$$

where A_O is the dc open-loop gain and, ω_T is the unity-gain radian frequency of the amplifier.

The fundamental assumption underlying this approximation is that the amplifier has a single-pole response. Thus, the closed-loop response as a function of frequency is given by

$$\text{closed-loop gain } A_{CL}(s) = \frac{1}{B}\left(\frac{1}{1+\frac{1}{A_OB}+\frac{1}{B\,\omega_T}s}\right).$$

As long as the loop gain is much greater than unity—which is usually the case—you can rewrite the expression as

$$\text{closed-loop gain } A_{CL}(s) \cong \frac{1}{B}\left(\frac{1}{1+\frac{1}{B\,\omega_T}s}\right).$$

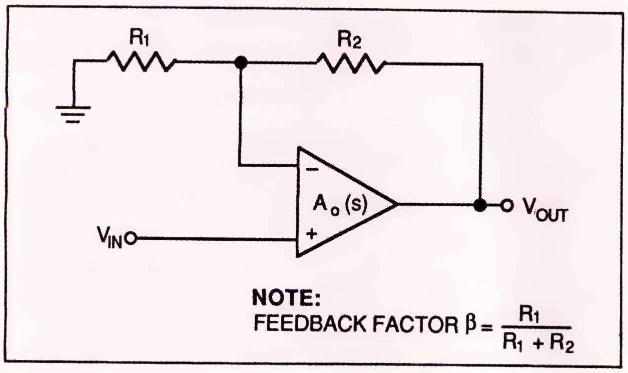

***Fig A—A basic single-stage amplifier** without any band-limiting circuit rolls off according to the closed-loop gain of the circuit and the amplifier's own natural frequency response.*

Fig B illustrates the magnitude and phase response of the closed-loop amplifier. Notice tha,t at the −3-dB corner frequency ω_c, the phase shift is −45°. Even at 1/10 of the corner frequency, the amplifier still has a 5.7° phase lag. The maximum frequency must be nearly two decades below the corner frequency to limit phase error to less than one degree.

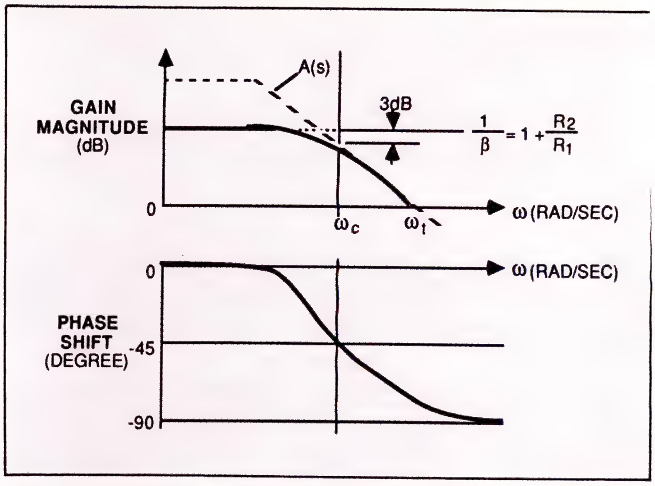

***Fig B—Magnitude and phase response** are shown for the basic single-stage amplifier. Notice that, at the −3-dB corner frequency ω_c, the phase shift is −45°.*

Fig 1 (pg 180) illustrates the second-order, active-feedback compensation circuit that you can model by writing the transfer equation for the two amplifier loops. In solving this equation, assume that each amplifier has a single-pole roll-off response and that the two amplifier responses match perfectly.

At the junction of R_1 and R_1/K_1, the resistor divider expression becomes

$$V_O\left(\frac{1}{1+K_2}\right).$$

Similarly, the resistor divider expression for R_2 and R_2/K_2 is

$$V_2\left(\frac{1}{1+K_2}\right).$$

For ac response, the loop equations can now be written:

$$A_1 \text{ loop: } V_O = \left[V_{IN} - \left(\frac{1}{1+K_2}\right)V_2\right]\frac{\omega_T}{s}$$

$$A_2 \text{ loop: } V_2 = \left[\left(\frac{1}{1+K_1}\right)V_O - \left(\frac{1}{1+K_2}\right)V_2\right]\frac{\omega_T}{s}.$$

Solving the simultaneous equations in terms of V_O and V_{IN}, the transfer function is,

$$\frac{V_O}{V_{IN}} = (1+K_1)\left[\frac{1+\frac{(1+K_2)}{\omega_T}s}{1+\frac{(1+K_1)}{\omega_T}s+\frac{(1+K_1)(1+K_2)}{\omega_T^2}s^2}\right].$$

Defining the time constants

$$T_1 = \frac{1+K_1}{\omega_T} \text{ and } T_2 = \frac{1+K_2}{\omega_T},$$

and substituting those time constants into the previous equations yields

$$\frac{V_O}{V_{IN}} = (1+K_1)\left[\frac{1+T_2s}{1+T_1s+T_1T_2s^2}\right].$$

For optimum compensation, the time constants T_1 and T_2 are made equal:

$$\frac{V_O}{V_{IN}} = (1 + K_1)\left[\frac{1 + Ts}{1 + Ts + T^2s^2}\right].$$

For sinusoidal input, where phase information is important, the complex frequency domain is used.

$$\frac{V_O}{V_{IN}}(j\omega) = (1 + K_1)\left[\frac{1 + jT\omega}{1 + jT\omega - T^2\omega^2}\right].$$

Now we calculate the complex conjugates to simplify:

$$\frac{V_O}{V_{IN}} = (1 + K_1)\left[\frac{(1 + jT\omega)(1 + T^2\omega^2 - jT\omega)}{(1 - T^2\omega^2)^2 + T^2\omega^2}\right]$$
$$= (1 + K_1)\left[\frac{1 - jT^3\omega^3}{1 - T^2\omega^2 + T^4\omega^4}\right].$$

From this equation, the magnitude error expression can be derived.

$$\text{magnitude error} = \left|\frac{1 - jT^3\omega^3}{1 - T^2\omega^2 + T^4\omega^4}\right| - 1$$

$$\text{for } T\omega << 1, \quad \cong \left|\frac{1}{1 - T^2\omega^2}\right| - 1$$
$$\cong 1 + T^2\omega^2 - 1$$
$$\cong T^2\omega^2.$$

Similiarly, the phase error expression can be derived.

$$\text{Phase error} = \text{ARC}\,(1 - jT^3\omega^3)$$
$$\cong -T^3\omega^3.$$

$T\omega$ relates to closed-loop gain as

$$\frac{1}{B} = 1 + K_1 = 1 + K_2,$$

therefore,

$$T\omega = \frac{\omega}{B\omega_T}$$

The transfer function can then be rewritten as

$$\frac{V_O}{V_{IN}} = \frac{1}{B}\left[\frac{1 - j\left(\frac{\omega}{B\,\omega_T}\right)^3}{1 - \left(\frac{\omega}{B\,\omega_T}\right)^2 + \left(\frac{\omega}{B\,\omega_T}\right)^4}\right].$$

Using this equation, the phase and magnitude behaviors as functions of frequency are tabulated in **Table A**. Note that, at ¹⁄₁₀ of the corner frequency, the compensated circuit produces a −0.057° phase shift, far superior to the −5.7° produced by the uncompensated circuit.

TABLE A—SECOND-ORDER COMPENSATION PHASE AND MAGNITUDE BEHAVIOR

$\frac{\omega}{\beta\omega_T}$	PHASE (DEGREE)	MAGNITUDE	20 LOG (MAG) IN dB
0.01	-5.7×10^{-5}	1.00000	0.0000
0.02	−0.0005	1.0004	0.0035
0.04	−0.00367	1.0016	0.0139
0.05	−0.00716	1.0025	0.0217
0.06	−0.01238	1.0036	0.0312
0.07	−0.01965	1.0049	0.0425
0.08	−0.0293	1.0064	0.0554
0.1	−0.0573	1.01	0.0864
0.2	−0.458	1.04	0.3404
0.3	−1.547	1.0896	0.745
0.4	−3.662	1.1576	1.271
0.5	−7.162	1.25	1.938
0.7	−14.428	1.37657	2.776
0.8	−27.1125	1.45979	3.2858
1.0	−45.0	1.4125	3.0

You can model the third-order compensation circuit of **Fig 10** (pg 186) in a similar way. Assume that all three op amps in the circuit have a single-pole roll-off in the frequency response represented by

$$A_O\,(s) \simeq \left(\frac{\omega_T}{s}\right)$$

where ω_T is the amplifier unity-gain crossover frequency.

For ac sinusoidal response, the loop equations can be written:

$$A_1 \text{ loop: } V_O = \frac{\omega_T}{s}\left[V_{IN} - \frac{1}{(1 + K_2)}V_2\right]$$
$$A_2 \text{ loop: } V_2 = \frac{\omega_T}{s}\left[\frac{1}{(1 + K_1)}V_O - \frac{1}{(1 + K_3)}V_3\right]$$
$$A_3 \text{ loop: } V_3 = \frac{\omega_T}{s}\left[\frac{1}{(1 + K_2)}V_2 - \frac{1}{(1 + K_3)}V_3\right].$$

Solving the three simultaneous equations in terms of V_O and V_{IN}, the transfer function is

$$\frac{V_O}{V_{IN}} = \frac{ax^2 + bx + 1}{ax^3 + bx^2 + \left(1 + \frac{1 + K_3}{1 + K_1}\right)X + \left(\frac{1}{1 + K_1}\right)},$$

where $a = (1 + K_2)(1 + K_3)$,
$b = 1 + K_2$
$X = \frac{S}{\omega_T}$

Box continued on pg 184

Box continued from pg 183

Define the time constants

$$T_1 = \frac{1 + K_1}{\omega_T},\ T_2 = \frac{1 + K_2}{\omega_T},$$

and $T_3 = \frac{1 + K_3}{\omega_T}$, then substitute,

$$\frac{V_O}{V_{IN}} =$$

$$(1 + K_1)\left[\frac{1 + T_2s + T_2T_3s^2}{1 + (T_1 + T_3)s + T_1T_2s^2 + T_1T_2T_3s^3}\right].$$

The dc gain of the amplifier is $(1 + K_1)$. And the ac response has the general form:

$$\frac{V_O}{V_{IN}} = (1 + K_1)\ \epsilon_p(s),$$

where

$$\epsilon_p(s) = \frac{1 + T_2s + T_2T_3s^2}{1 + (T_1 + T_3)s + T_1T_2s^2 + T_1T_2T_3s^3}.$$

Solve for ac response in terms of T_1, T_2, and T_3.

$$\epsilon_p(j\omega) =$$

$$\frac{1 - T_2T_3\omega^2 + jT_2\omega}{1 - T_1T_2\omega^2 + j[(T_1 + T_3)\omega - T_1T_2T_3\omega^3]}.$$

Defining:

$a = 1 - T_2T_3\omega^2$, $b = T_2\omega$

$c = 1 - T_1T_2\omega^2$, $d = (T_1 + T_3)\omega - T_1T_2T_3\omega^3$

$$\epsilon_p(j\omega) = \frac{a + jb}{c + jd} = \frac{ac + bd + j(bc - ad)}{c^2 + d^2}.$$

The numerator determines the phase shift of the amplifier. Solve the numerator of $\epsilon_p(j\omega)$:

$$\epsilon_p(j\omega) = 1 + j\,[(T_2 - T_1 - T_3)\omega - (T_1T_2^2 - T_2T_3^2 - 2T_1T_2T_3)\omega^3 - T_1T_2^2T_3^2\omega^5.$$

To minimize phase shift, make $T_2 - T_1 - T_3 = 0$, and

numerator $\epsilon_p(j\omega) =$

$$1 + j[(- T_2)(T_1T_2 - 2T_1T_3 - T_3^2)\omega^3 - T_1T_2^2T_3^2\omega^5].$$

The objective is to eliminate the ω^3 term:

$$- T_2\,[T_1\,(T_2 - 2T_3) - T_3^2]\rightarrow 0.$$

First substitute $T_1 + T_3$ for T_2, then let $T_3 = \alpha T_1$. Set the equation equal to zero and solve for α.

$$- (T_1 + \alpha T_1)\,[T_1(T_1 - \alpha T_1) - (\alpha T_1)^2] = 0$$

$$\alpha^2 + \alpha - 1 = 0$$

Solving α for the two roots, you obtain

$\alpha = 0.618034$

$\alpha = - 1.618034$

For minimum phase shift, the relationships $T_1 + T_3 = T_2$ and $T_3 = 0.618T_1$, are used.

$T_1 = T$

$T_2 = 1.618034T$

$T_3 = 0.618034T$,

recalling that $T_1 = \frac{1 + K_1}{\omega_T}$, $T_2 = \frac{1 + K_2}{\omega_T}$, and $T_3 = \frac{1 + K_3}{\omega_T}$.

Since K_1 relates to the dc gain $1/B$ of the amplifier as $(1 + K_1) = 1/B$, the design equations are:

$$K_1 = \frac{1}{B} - 1.$$

Substituting and solving for K_2 and K_3 in terms of K_1,

$K_2 = 1.618034\ K_1 + 0.618034$

$K_3 = 0.618034\ K_1 - 0.382.$

These three last design equations produce optimum phase cancellation for an amplifier with any gain. For example, for an amplifier gain of 10, $K_1 = 9$, $K_2 = 15.18$, and $K_3 = 5.18$.

In order to derive the complete transfer function, the denominator is similarly solved. Therefore, with

denominator $\epsilon_p(j\omega) =$

$$1 - 0.618T^2\omega^2 - 0.618T^4\omega^4 + T^6\omega^6,$$

the complete ac response is:

$$\epsilon_p(j\omega) =$$

$$\frac{1 - j(T\omega)^5}{1 - 0.618034\,(T\omega)^2 - 0.618034\,(T\omega)^4 - (T\omega)^6}$$

Finally, the complete amplifier transfer function is,

$$\frac{V_O}{V_{IN}} =$$

$$(1+K_1)\left[\frac{1 - j(T\omega)^5}{1-0.618034(T\omega)^2-0.618034(T\omega)^4-(T\omega)^6}\right].$$

Active feedback can overcome the temperature-drift problem associated with RC networks.

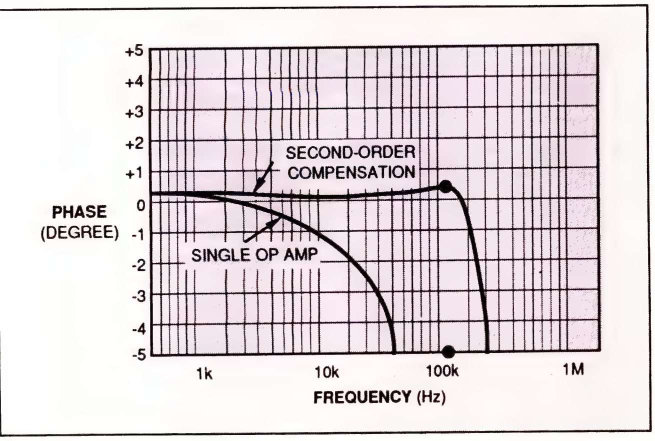

Fig 6—Slight peaking in the phase response at 100 kHz *for the second-order-compensated circuit is illustrated in this closeup view of* **Fig 5.**

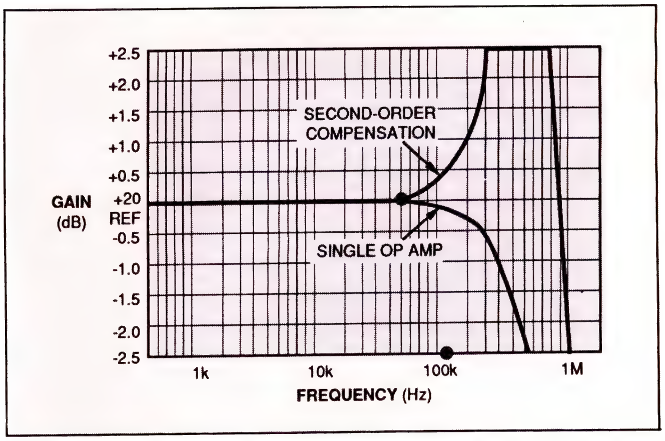

Fig 8—Taking a closer look at the magnitude response, *you see that below 100 kHz, the frequency range where phase error is negligible, only a small degradation in gain accuracy occurs.*

−45° and 135°, respectively. The second-order response runs virtually flat with negligible phase shift to a much higher frequency before bandwidth limitation sets in. The roll-off is much steeper for the the second-order system than for the single-stage system. **Fig 6** illustrates more clearly that the second-order circuit's phase error remains nearly zero out to 100 kHz, while the single-stage amplifier's low phase-shift bandwidth is limited to 2 kHz.

Fig 6 also reveals a slight amount of phase peaking at about 100 kHz, just before the response rolls off. The peaking stems from the op amps' second poles near the unity-gain frequency. With a closed-loop gain of 10, the dominant pole and the second pole are separated by only one decade in frequency. This proximity causes secondary effects on the phase response of the amplifier. However, if you increase the closed-loop gain of the circuit, you further separate the two poles, reducing the second-pole effect.

Fortunately, the second-order compensation's improvement in phase error does not exact much of a penalty in magnitude error. **Fig 7** charts the magnitude response versus frequency. Some gain peaking is apparent, but as predicted, the peaking occurs well beyond the amplifier's useful bandwidth. (**Fig 8** shows a close up of the gain peaking for the second-order-compensated circuit.) In the frequency range below 100 kHz, gain error is held to less than 0.25 dB or 3%. In comparison to the single-stage approach, a second-order compensation offers both low phase error and low magnitude error over a significantly expanded bandwidth.

Either resistor tolerances or op-amp mismatches can degrade the compensation circuit's performance but to no great extent. What does make a big difference is variations in K_2 **(Fig 9).** If you assume that the op amps

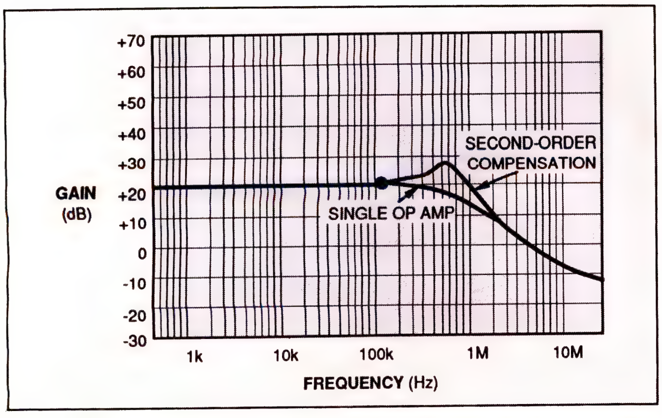

Fig 7—The magnitude response *of the second-order-compensated circuit exhibits peaking at a frequency that is well beyond the useful range of the circuit.*

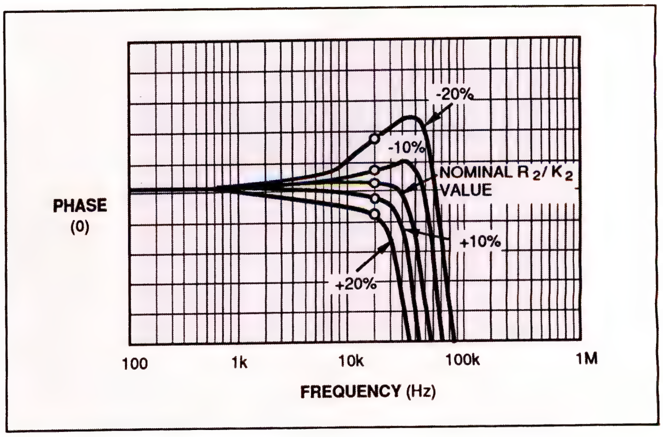

Fig 9—Phase-response sensitivity *to variations in the compensation resistor ratio results in slight over- and undercompensation.*

Theoretically, second-order compensation works for any closed-loop gain.

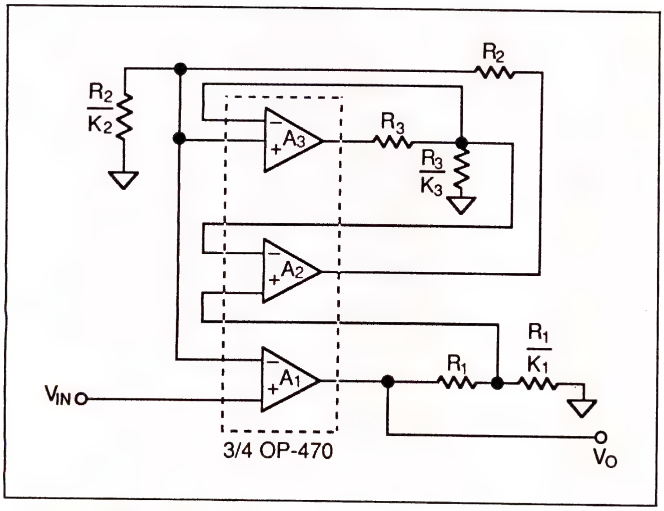

*Fig 10—**Third-order compensation** takes the concept of active feedback one step further, adding another level of compensation to the feedback path.*

in **Fig 1** match perfectly, the resistor ratio, K_2, is the only variable that affects the amount of phase compensation that the feedback circuit provides. If you decrease K_2, the gain of op amp A_2 is also decreased; in turn, the dominant pole of A_2 shifts to a higher frequency, thereby decreasing the compensation. In the extreme case, where op amp A_2's gain is reduced to unity, the circuit behaves as if it had no compensation at all. It then responds as a single-stage amplifier. On the other hand, if you increase K_2, the gain of A_2 is likewise increased, and A_2's bandwidth decreases; overcompensation results. The end effect is that phase and gain peak more.

Third-order compensation, which requires another op amp and two resistors in the feedback path, provides even greater phase compensation than afforded by second-order compensation. The schematic for the third-order compensation circuit is given in **Fig 10.** The additional compensation comes from op amp A_3 in the feedback path of op amp A_2. The basic circuit is the same as that of the second-order compensation circuit.

TABLE 2—ERROR COMPARISON OF SECOND-ORDER VS THIRD-ORDER COMPENSATION

	SECOND-ORDER	THIRD-ORDER
CLOSED-LOOP GAIN	$\frac{1}{\beta}$	$\frac{1}{\beta}$
MAGNITUDE ERROR	$\left(\frac{\omega}{\beta\omega_T}\right)^2$	$0.618\left(\frac{\omega}{\beta\omega_T}\right)^2$
PHASE ERROR	$-\left(\frac{\omega}{\beta\omega_T}\right)^3$	$-\left(\frac{\omega}{\beta\omega_T}\right)^5$

The sinusoidal transfer function when the phase difference is minimized may be written:

$$\frac{V_O}{V_{IN}} = (1+K_1)\left[\frac{1 - j(T\omega)^5}{1-0.618034(T\omega)^2-0.618034(T\omega)^4-(T\omega)^6}\right]$$

where: $T = \frac{1}{B\omega_T}$.

The numerator contains the phase information and the denominator contains the magnitude information. **Table 2** contrasts the magnitude and phase errors for the second-order response with that of the third-order response. Magnitude error is 38% lower for third-order compensation. Phase error is reduced from a third-order to a fifth-order term.

The third-order frequency response is plotted in **Fig 11** in comparison to that of the second-order compensation and of the single op-amp design. Given a prescribed error band—for example, one degree of phase error—third-order compensation doubles the effective bandwidth of an amplifier design over the second-order compensation technique.

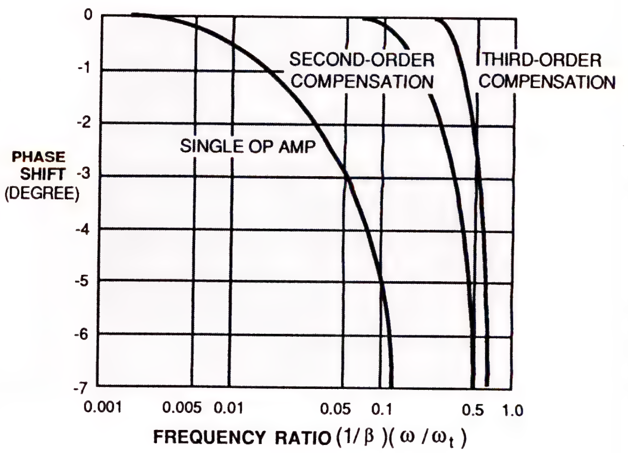

***Fig 11—For a given phase error, the third-order compensation technique** offers twice the bandwidth that the second-order technique does.*

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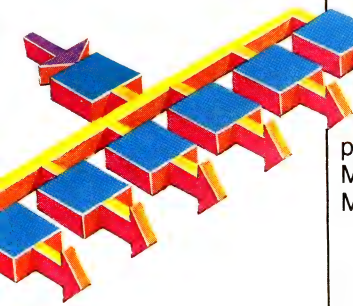

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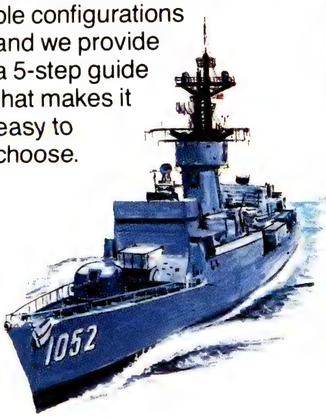

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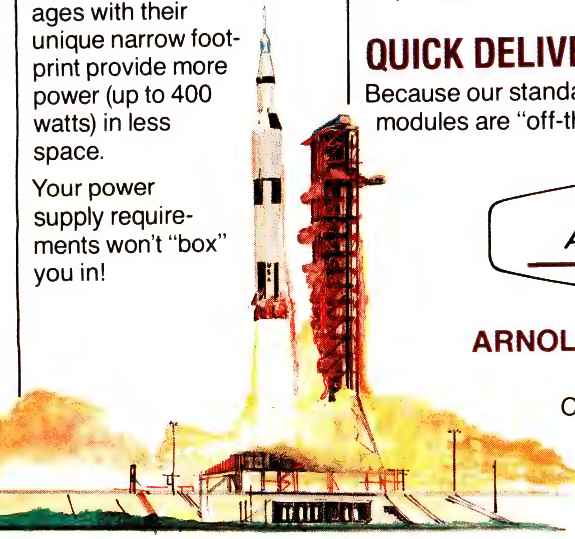

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As you might imagine, the extra op amp in the feedback loop causes the gain to peak more at the −45° corner frequency. However, in the frequency range where phase error is minimal, gain accuracy is also improved. At a frequency ratio below 0.1, magnitude errors do not exceed 0.1 dB.

Fig 12 shows a test circuit that implements the third-order compensation. The phase response, measured by a network analyzer, is compared to that of the second-order compensation and of a single-op-amp design in **Fig 13**. The phase response of the third-order design remains flat beyond 400 kHz, double the 200 kHz provided by the second-order design. The magnitude response, on the other hand, has considerably higher peaking than the second-order design, but below 350 kHz, the third-order design actually provides lower magnitude error than does the second-order design. **EDN**

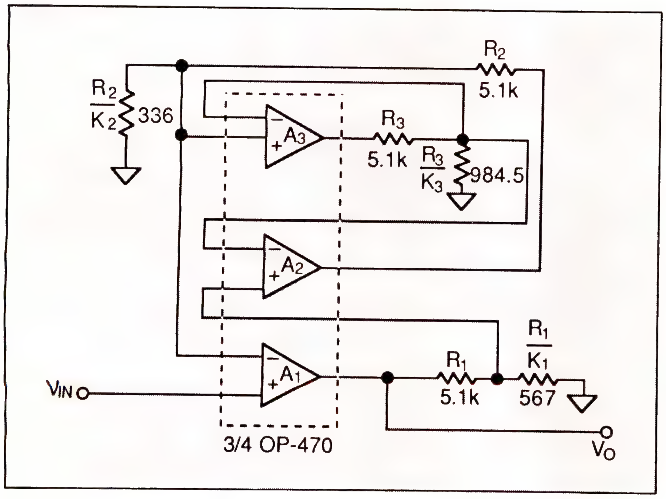


***Fig 12—A third-order compensation circuit** with component values that set a gain of 10 for the amplifier is illustrated here.*

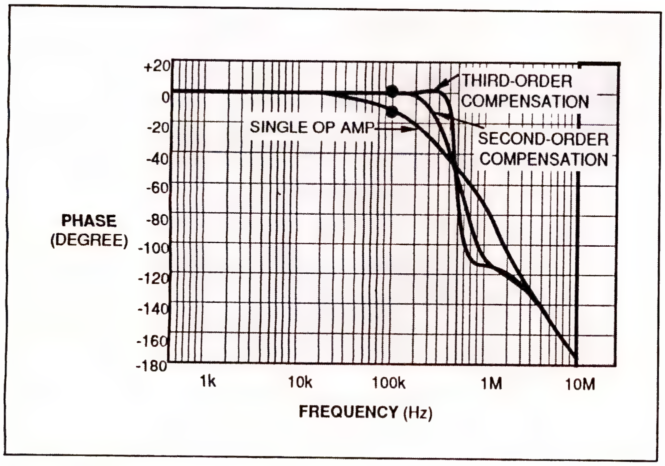
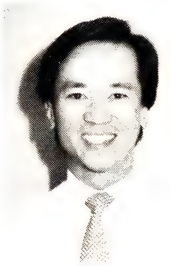


***Fig 13—The actual phase response of the third-order circuit** remains flat to a higher frequency than the second-order circuit or the single-op-amp design.*

Author's biography



James Wong is an applications engineering manager at Precision Monolithics Inc in Santa Clara, CA. He holds a BSEE degree from San Jose State University and an MBA from Santa Clara University. In his spare time, he enjoys golfing.

References

1. Soliman, Ahmed M, "Design of High-Frequency Amplifiers," *IEEE Circuits and Systems*, June 1983.
2. Soliman, A M and Ismail, M, "Active Compensation of Op Amps," *IEEE Transactions on Circuits and Systems*, February 1979.

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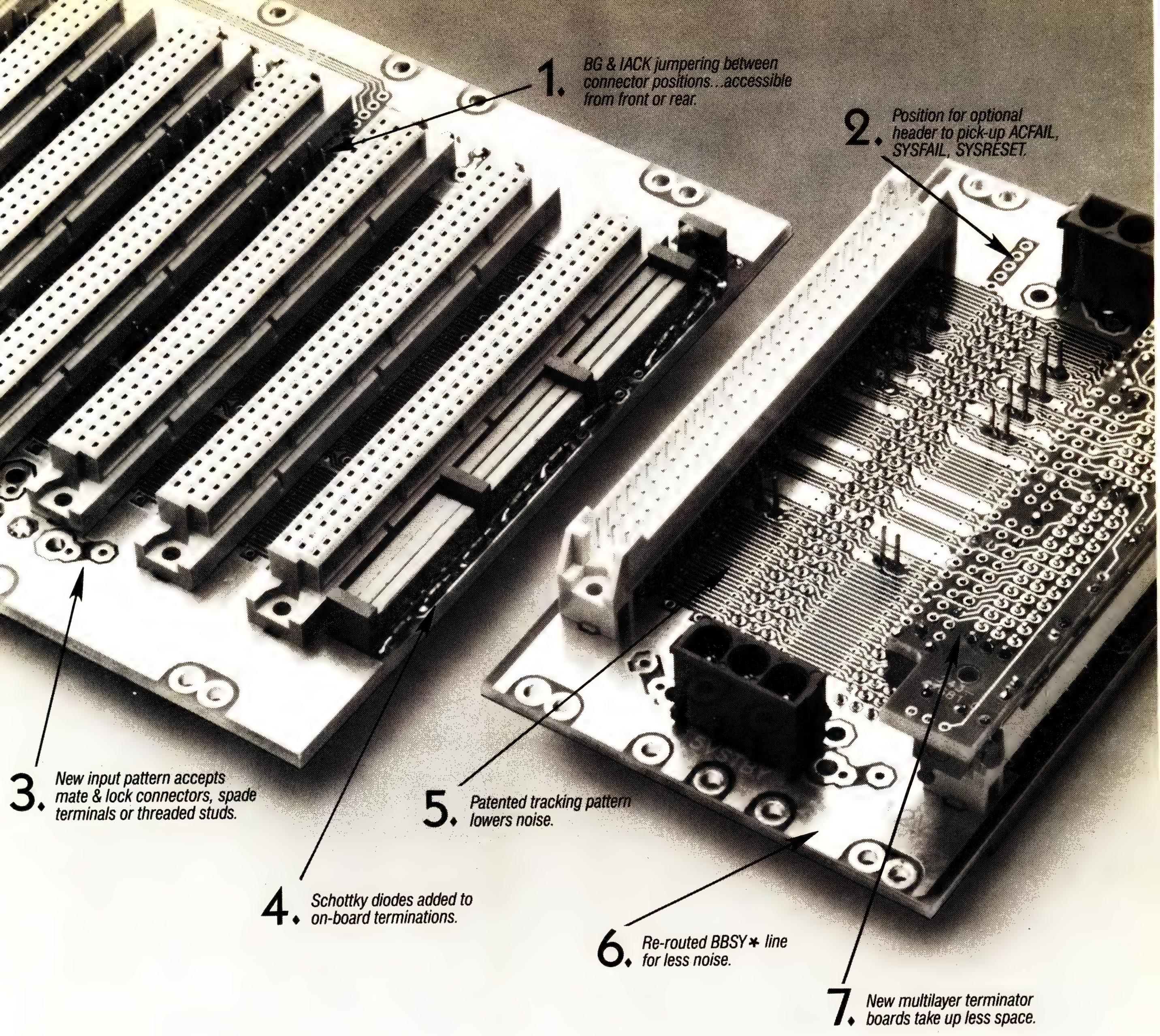
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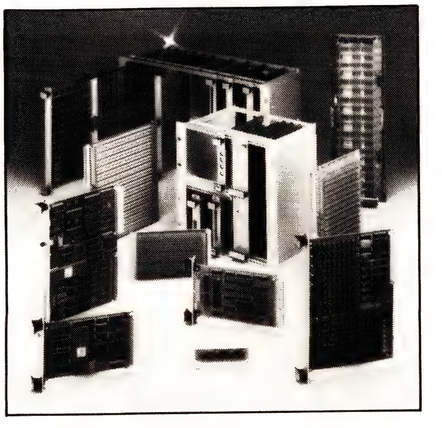

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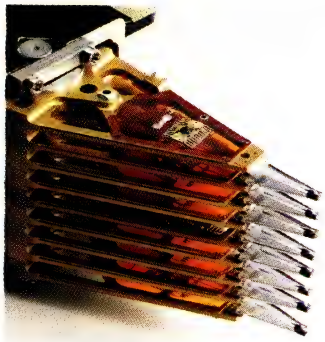

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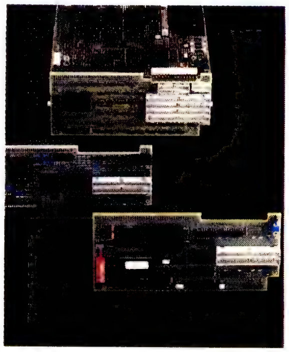

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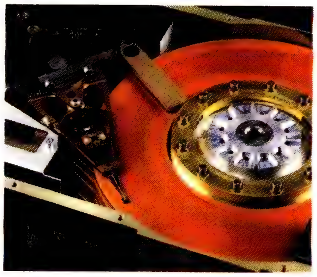

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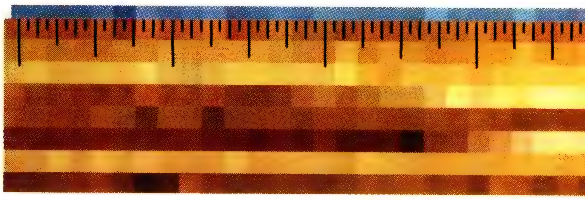

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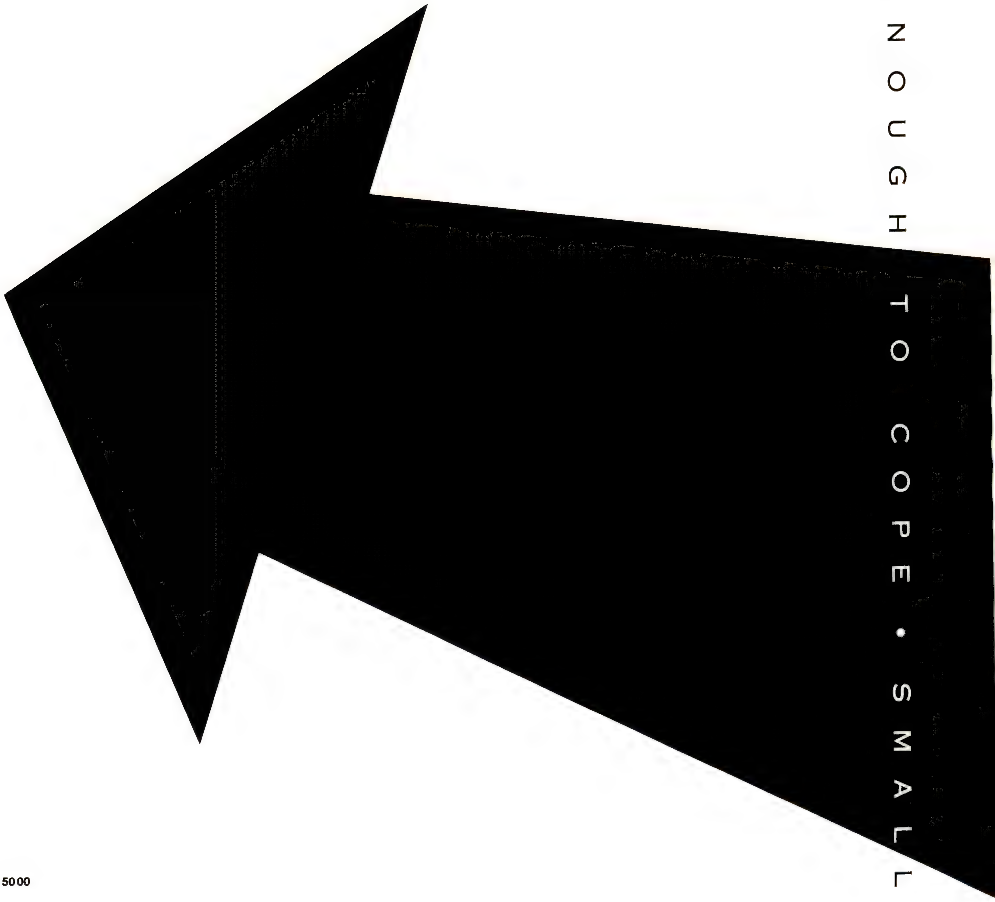

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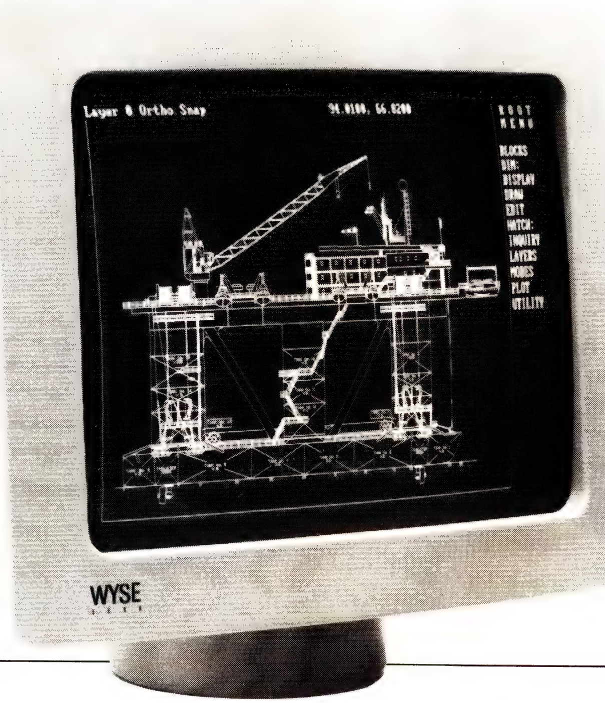

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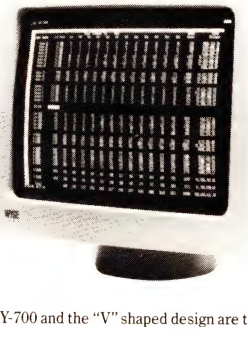

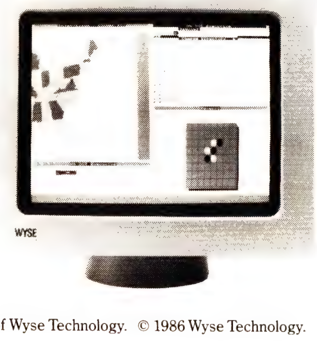

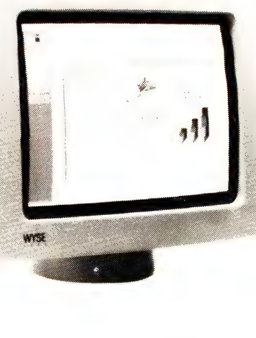

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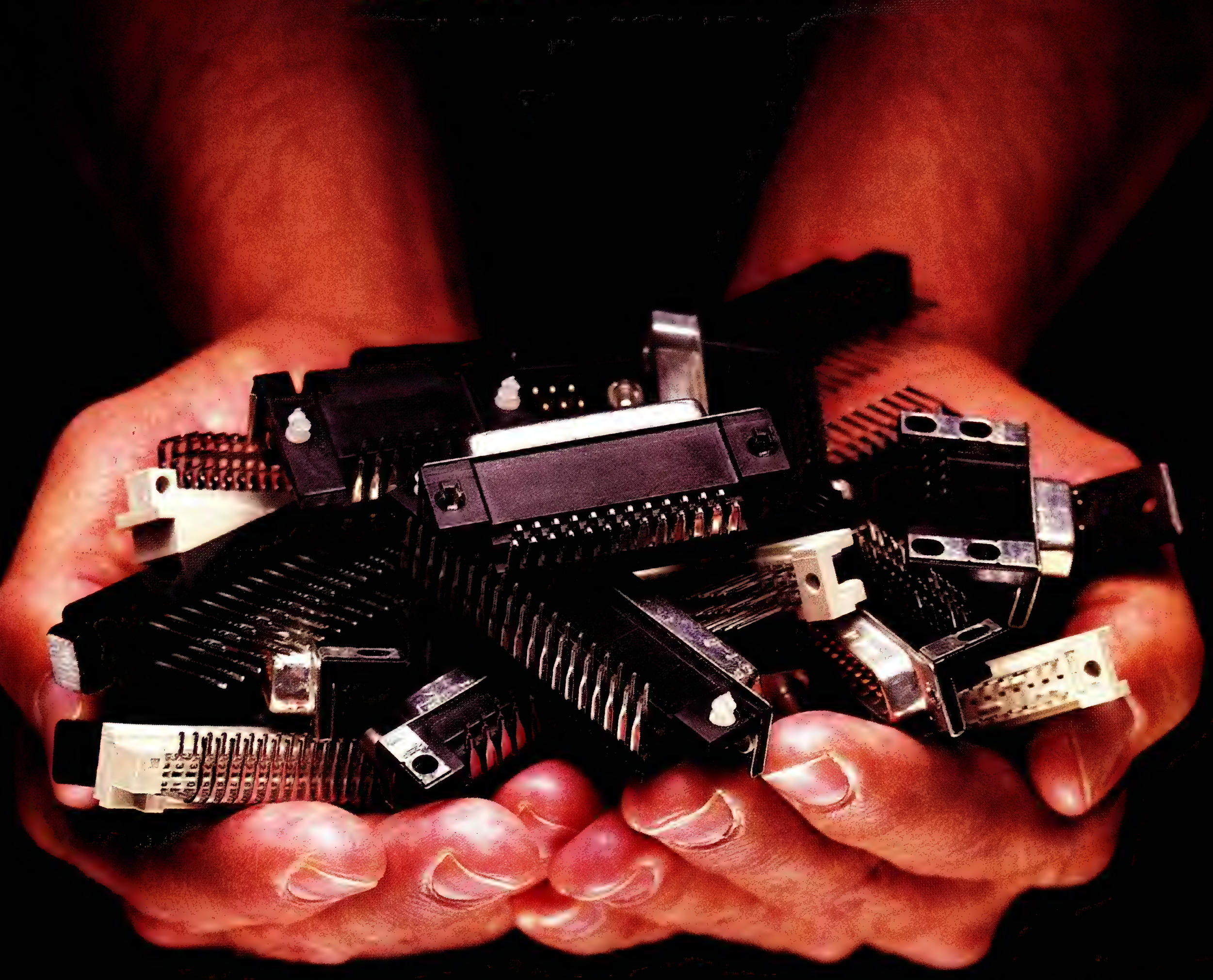

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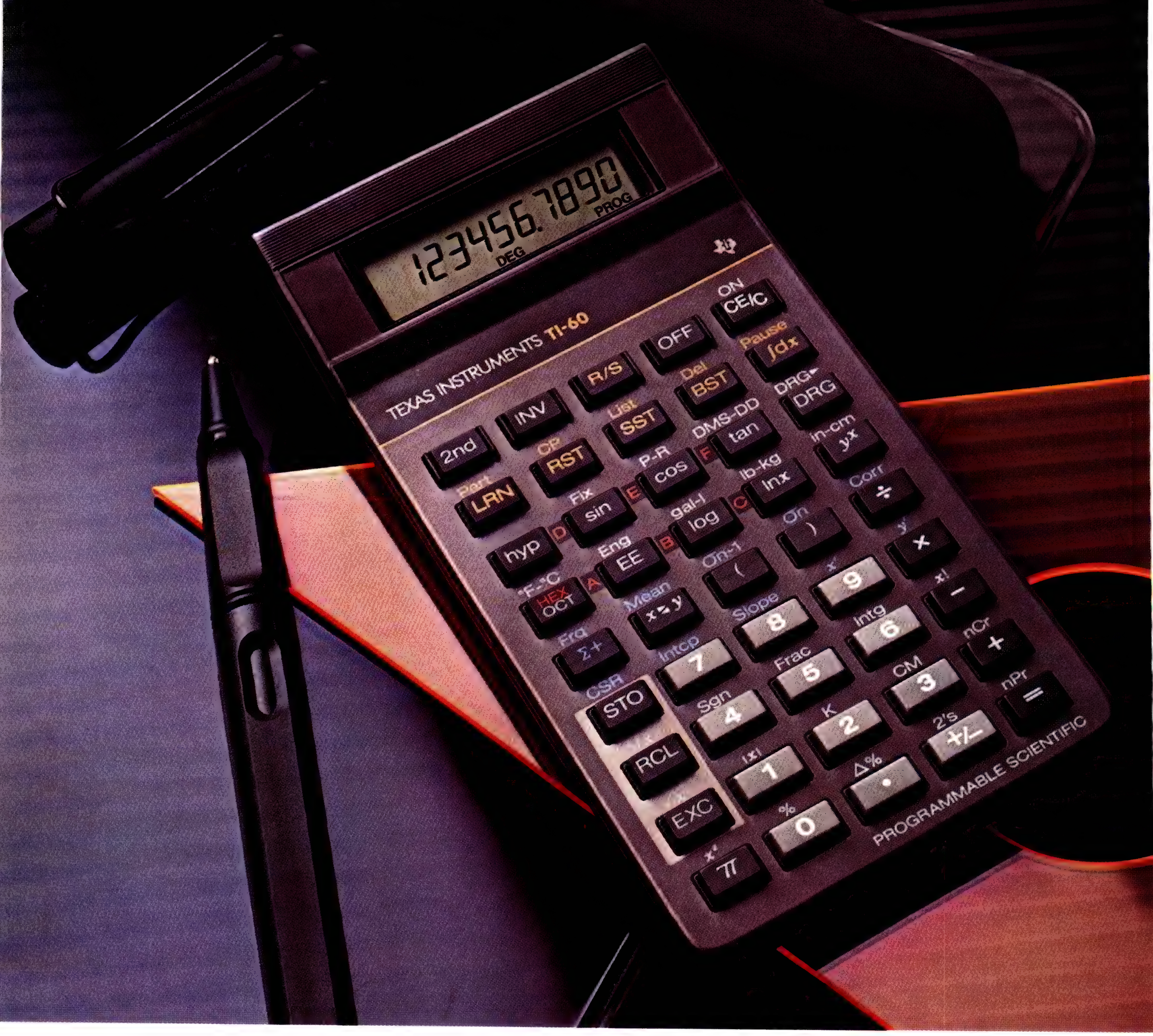

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When you're designing a system, you must often pass analog signals between one system component and another where the two components may not share a common ground. A common-mode potential between the two components can be either a fault condition or normal operation. Isolation amplifiers (isolators) provide the best means of transferring analog information when you must guarantee the absence of any galvanic connection between the two components.

You typically need an isolation amplifier for one of three reasons. First, you'd use an isolator when you need a differential amplifier, yet the required common-mode range rules out traditional modular or monolithic differential or instrumentation amplifiers. An isolator's high common-mode-voltage rating permits a differential signal to exist in the presence of common-mode voltages of several hundred volts. Second, in circuits in which no common-mode potential is present during normal operation, you can use an isolator to provide protection against a fault condition. Third, isolators can eliminate any possibility of current flow between two points; this capability is important in medical applications, for example, where a few milliamps can be fatal.

Instead of using an optically coupled or capacitively coupled isolator, which require external power supplies and exhibit performance limitations, you can use a device such as the AD210 3-port isolation amplifier (**Fig 1**), which is constructed of surface-mount components and assembled automatically. The AD210 combines 2500V rms isolation with an input offset voltage of 15 mV maximum, an input offset-voltage drift of 10 μV/°C, and a gain temperature coefficient of 25 ppm/°C max.

You can use the isolator without an external input amplifier in applications requiring gains of 1 to 100. The device's linearity is ±0.012% of the output span, rendering the device transparent for applications requiring as much as 12 bits of accuracy. Furthermore, its large-signal −3-dB bandwidth is 20 kHz, which is several times higher than that of most of today's high-performance isolators.

The device is a functionally complete isolation amplifier. Two isolated bipolar power supplies (±15V) are available to the input and output circuitry. Additionally, the isolated power (±5 mA) is available to support signal conditioning and adjustments without external dc/dc converters. The AD210 also incorporates an uncommitted FET-input op amp to provide gain as well as calibration functions.

As **Fig 1** shows, a 15V differential applied to pins 29 and 30 drives a 50-kHz power oscillator. The output of

An isolator can eliminate any possibility of current flow between two points, such as in a medical application, where a few milliamps can be fatal.

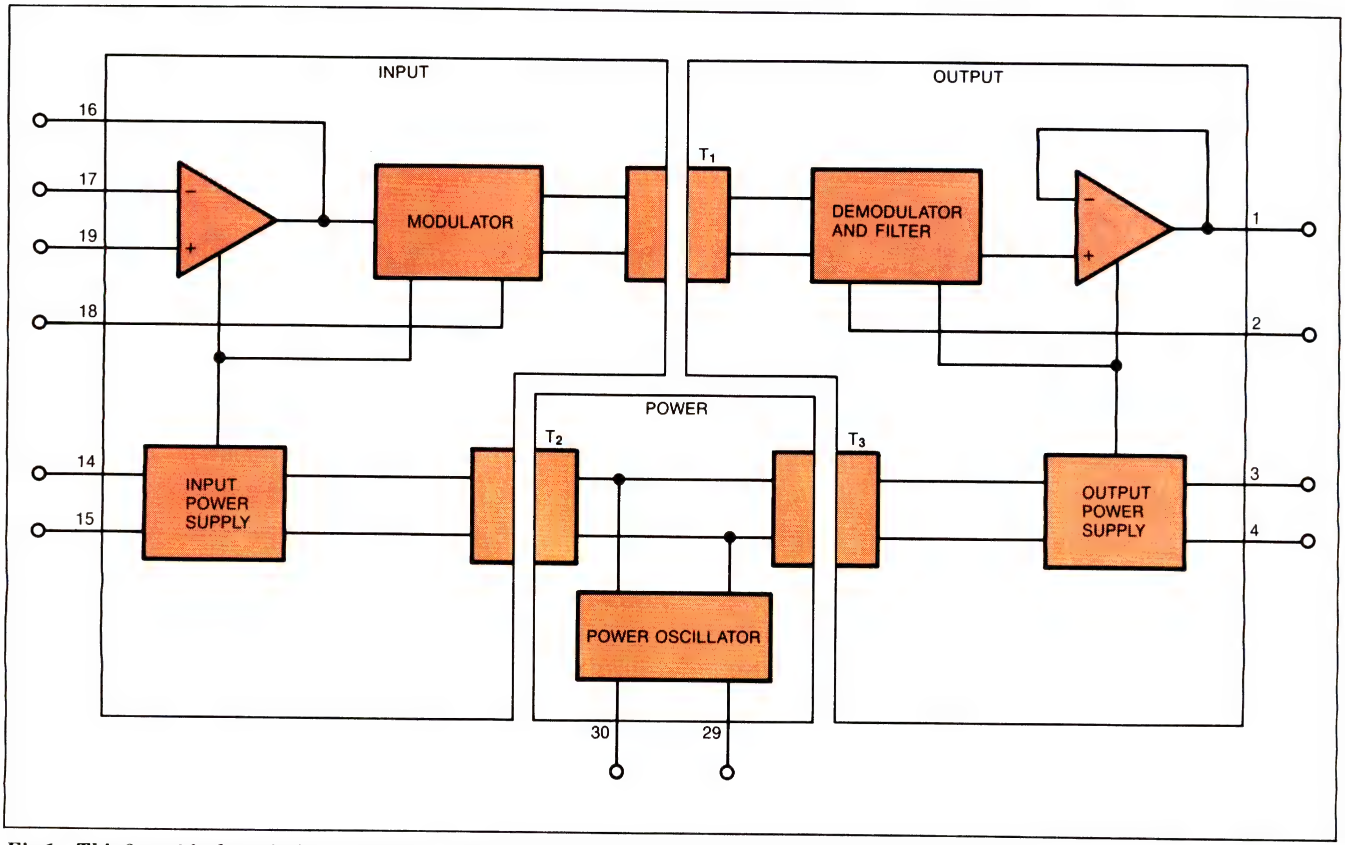


***Fig 1—This 3-port isolator** isolates the input, output, and power ports of a system. Wire-wound transformers couple signals and power across the isolation barriers.*

the oscillator drives transformers T_2 and T_3, whose secondary outputs undergo rectification and filtering to provide unregulated power to the input and output ports. You can configure the input op amp to provide gain, offset, and signal-conditioning functions. Its output amplitude-modulates the 50-kHz carrier frequency that passes through signal transformer T_1. The timing information provided by power transformer T_3 performs synchronous, full-wave demodulation of the signal from T_1. Following the demodulator is a 3-pole, buffered, 20-kHz lowpass filter. From the output of the input amplifier to the output of the AD210, the isolator is a unity-gain device.

Trimmable input buffer provides gain

As **Fig 2** illustrates, you can use the isolator as a high-input-impedance buffer with gain. You configure the internal input amplifier as a noninverting amplifier with an approximate gain of $(50k+R_G)/R_G$. The 5k trim potentiometer compensates for the initial gain-accuracy error of the AD210 (2% for the AD210A, 1% for the AD210B) and the ratio error of the gain-setting resistors. At gains of less than 5, the reduction in the potentiometer's adjustment range may warrant altering the potentiometer's value.

The offset adjustment scheme shown connects the offset-correction voltage in series with the common side of the signal source. This scheme works only if the input source has no other current path to input common. To provide a bipolar offset adjustment with stable temperature characteristics, you connect the offset-adjustment potentiometer to the pair of temperature-compensated zener diodes, D_3 and D_4.

D_3 and D_4 are also an integral part of a normal-mode protection scheme. Assuming the input signal remains within ±5V of input common, low-leakage diodes D_1 and D_2 are reverse biased and do not affect the operation of the circuit. However, should the input signal exceed either zener voltage, the diode begins to conduct and limits the AD210's input voltage to the zener voltage plus a diode drop. In fact, you can apply 130V rms continuously to the input of this circuit and not exceed the power limit of R_1. The voltage rating of this 40-kΩ, ½W resistor must exceed the maximum ex-

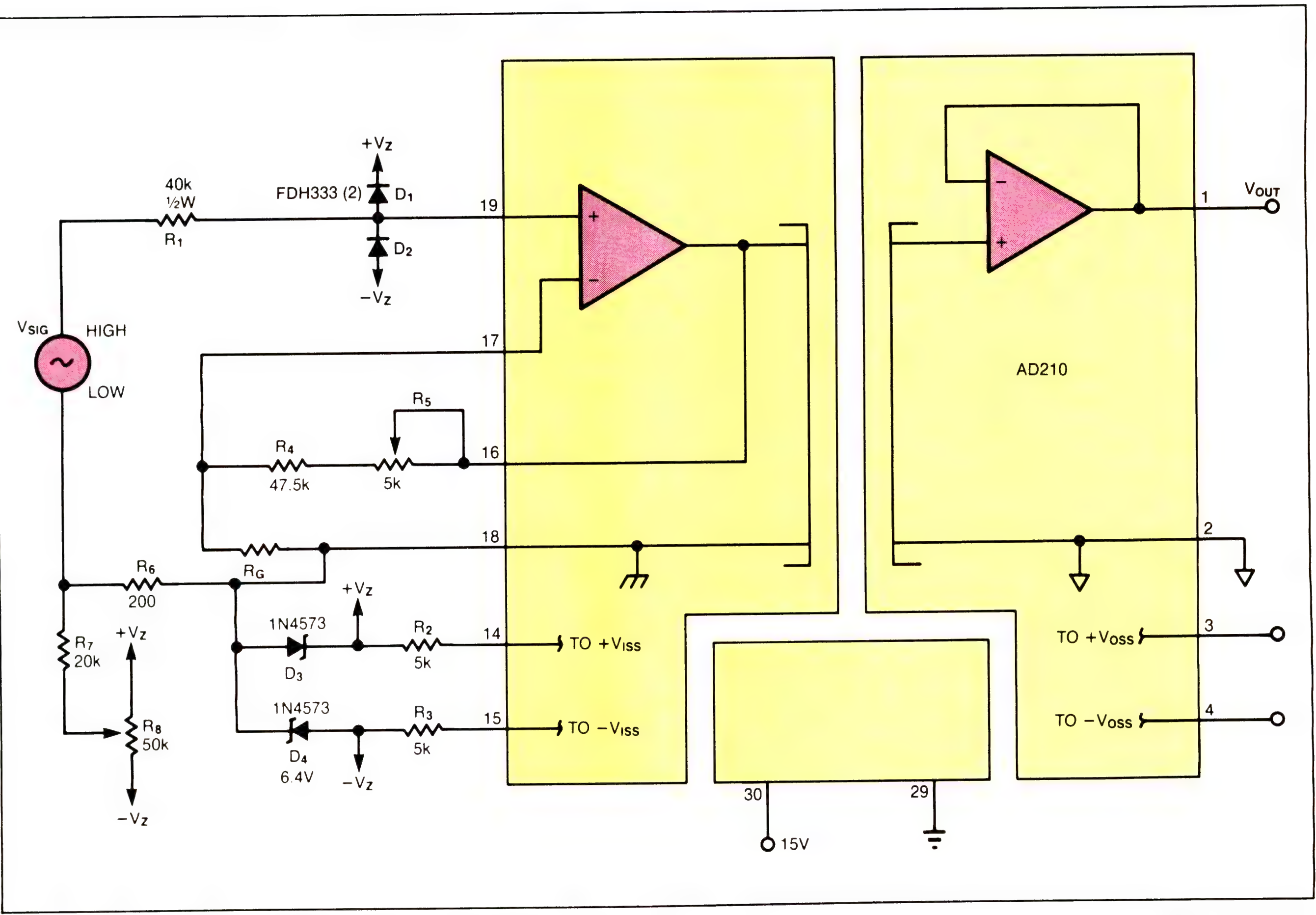


***Fig 2—Passive components protect the isolator's input** against 130V rms normal-mode signals. You can trim the gain and offset to 0.01% of the signal span.*

pected fault-condition voltage. As soon as the input voltage returns to within the clamp limits, the protected buffer will function normally.

Should you desire an inverting gain, you simply reverse the input leads, because the input of the AD210 shares no common ground with the external circuitry. If additional connections prevent you from reversing the input leads, you can reverse the output leads, because the AD210 is a 3-port isolator. The device's own isolation properties provide the 2500V rms continuous common-mode protection.

Isolated current source supplies 1 to 5 mA

You can employ the output circuit shown in **Fig 3** to create a self-powered output-current source. The AD210's isolated power ($+V_{OSS}$ and $-V_{OSS}$) operates IC_1. Resistor R_1 converts the output voltage of the isolator to an equivalent current of $V_{OUT}/2k$, directly affecting the gain of the current-output device and its thermal stability. You can adjust the initial gain accuracy of the output device, but its thermal drift must be low enough for the application.

All of the current flowing through R_1—except the bias current of IC_1, the leakage current of D_1, and the base current of the output Darlington pair (Q_1 and Q_2)—flows through the Darlington pass devices. IC_1 has a low bias current, and D_1 is a low-leakage diode. The Darlington configuration minimizes the loss of current to the transistor's base. The low-leakage diode, D_1, protects the base-emitter junction from reverse bias voltages. Using $-V_{OSS}$ as a current return provides more than 10V of compliance for the current source, because the output port is completely isolated.

You can implement offset and gain control either at the input of the AD210, or by adjusting R_1 and summing a correction current into the summing node of IC_1. The nominal current range for this circuit is 1 to 5 mA because bias and leakage currents place a lower limit on

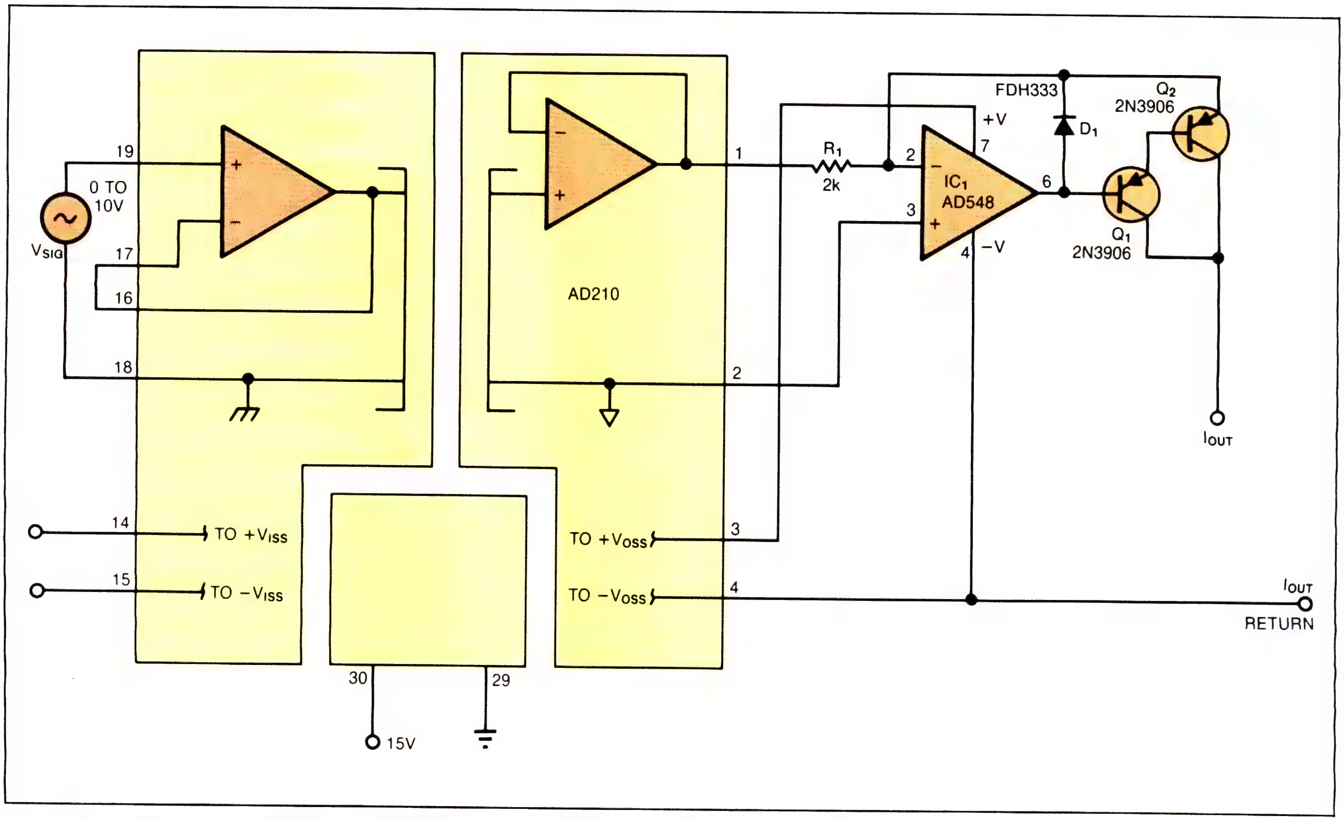


*Fig 3—**In addition to measuring input signals in the presence of high common-mode voltages,** a 3-port isolator can generate high-level voltage and current outputs. This circuit produces a 0- to 5-mA current with more than 10V of compliance.*

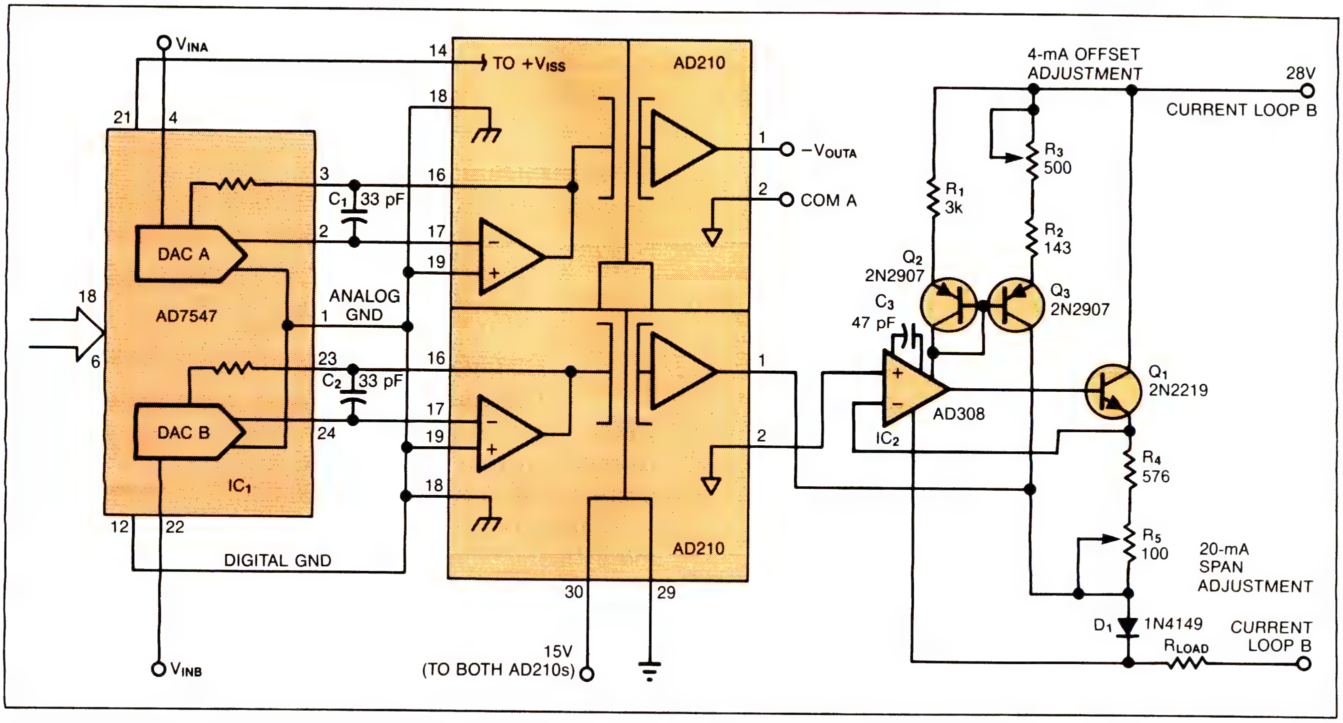


*Fig 4—**A dual D/A converter and two isolators** deliver programmable isolated outputs of 0 to 10V and 4 to 20 mA.*

An isolator can work as a high-input-impedance buffer with gain or as a self-powered output-current source.

he output current. You can detect a broken connection nywhere in the current loop by the absence of output urrent. If you power the AD210 from the input potenial, this circuit will provide a fully isolated, wide-bandwidth current output.

Dual isolated outputs are programmable

A pair of isolators in conjunction with an AD7547 dual 12-bit D/A converter can provide a dual, 12-bit, programmable isolated-output device (**Fig 4**). The outputs are a low-impedance, isolated analog voltage whose amplitude is proportional to the digital input ignal multiplied by analog input voltage V_{INA}, and a 4-o 20-mA current loop that's proportional to the digital nput multiplied by V_{INB}.

The inputs of IC_1 are TTL or CMOS compatible. To provide a ground reference for the digital input signals, you should tie the input common of the AD210s to both the digital and analog commons of IC_1. The $+V_{ISS}$ of one of the AD210s powers the dual DAC. You can use the two analog inputs of IC_1 either with a reference (powered by one of the isolated input supplies of the AD210s) or as varying analog inputs that are multiplied by the digital inputs (IC_1 is a multiplying DAC). The voltage connected to V_{INB} is usually a 10V dc reference, and the AD210 output applied to the current-loop device is unipolar.

The input amplifiers of the isolators convert the output currents of the DACs to a voltage. If the offset voltage of the AD210's input amplifiers is too high for the application, you can zero it out by injecting a small current into the inverting-input node (pin 17).

The voltage output of channel A is labeled as $-V_{OUTA}$, because the input amplifier of the isolator acts as an inverter, and the polarity of the output voltage will be the opposite of V_{INA}'s. You can negate the inversion by interchanging the output and output-common pins of the 3-port isolator.

You connect channel B of IC_1 to another isolator whose output drives a 4- to 20-mA current-loop device. When a 10V reference is connected to V_{INB}, the output of the AD210 varies between 0 and −10V. If you swap

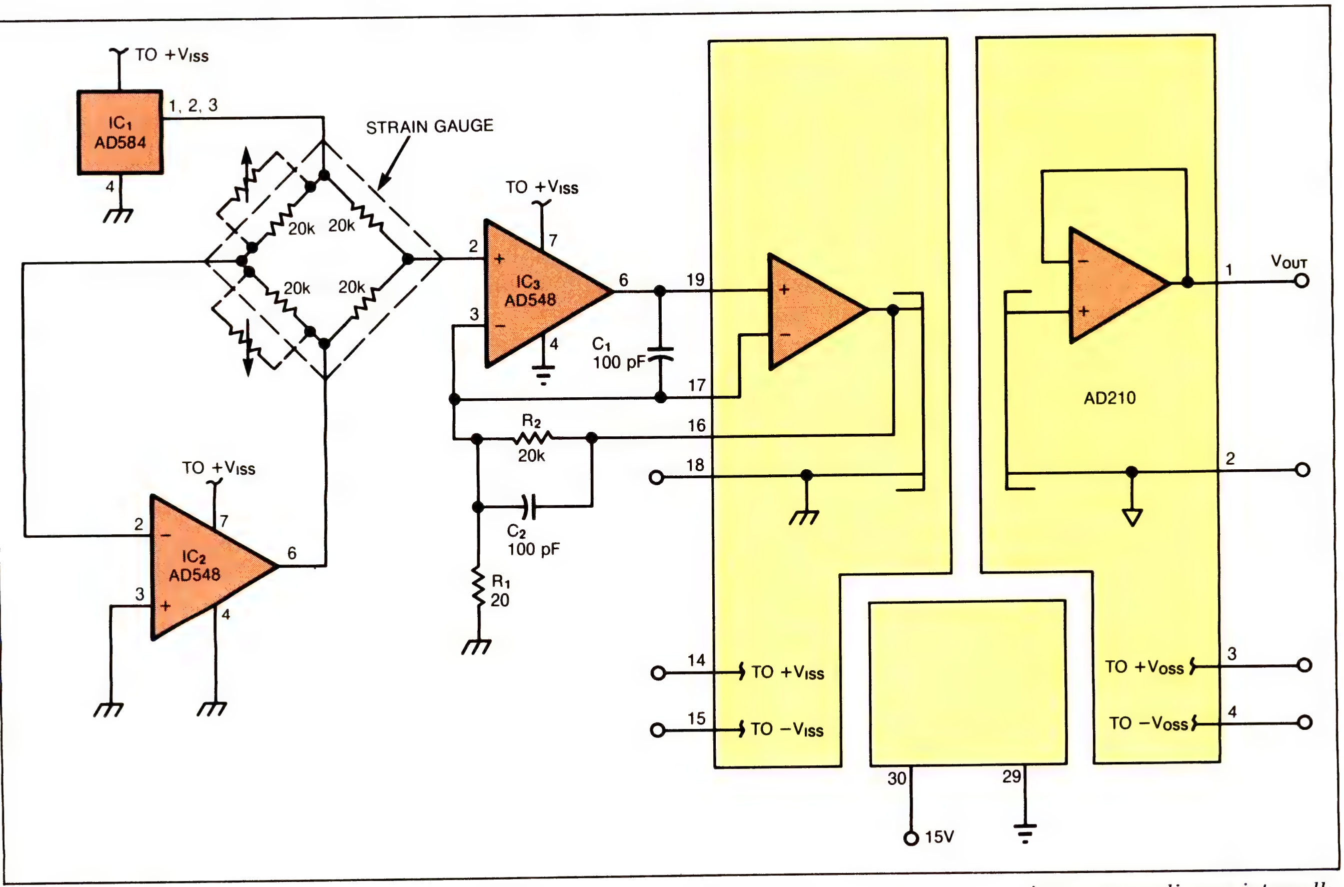


*Fig 5—**This wideband strain-gauge circuit** yields a −3-dB bandwidth of 10 kHz at a gain of 1000. Because its power supplies are internally isolated, the circuit eliminates the need for a separate dc/dc converter to run the strain-gauge circuitry.*

A pair of isolators and a dual, 12-bit D/A converter can provide a dual, 12-bit, programmable isolated-output device.

the output leads of the AD210, its output will vary between 0 and 10V. Such swapping is possible because of the complete isolation of the AD210.

The current mirror, formed by Q_2 and Q_3 and their emitter resistors, multiplies the power-supply current of IC_2. Resistor R_3 adjusts this current to a value of 4 mA. The input voltage applied to the current-loop device appears across the 576Ω resistor (R_4) and the 100Ω potentiometer (R_5) to create a 16-mA span. The 1N4149 diode keeps the output of IC_2 in the linea region at very small input-voltage signals. You shoul adjust the 4-mA offset with a nominal AD210 output o 0V, and the current span to 20 mA with a −10V outpu from the isolator.

Stable reference drives strain gauge

Fig 5 shows how you can use the AD210 to implement a wideband strain-gauge circuit that yields a −3-dB

Isolation-amplifier terminology

When you're comparing data sheets for isolation amplifiers, you'll find that manufacturers use some specialized terms to characterize these devices. Although specification parameters for isolators may vary from manufacturer to manufacturer, the following list of terms can help you extract meaningful information from isolator data sheets.

Aliasing is the creation of a difference frequency in the output. Some types of isolators contain clocks that can cause aliasing. These isolators typically maintain a higher clock frequency than the input signal bandwidth, and they usually include either an antialiasing lowpass filter or provisions for one.

Breakdown voltage is the voltage at which current begins to conduct between ports. When you're designing with an isolation amplifier, it's always best to maintain a safety margin. Many standards organizations have adopted guidelines for safety margins, which depend on the application. For example, an isolator intended for medical purposes usually requires a wider safety margin than one used in an industrial application.

Common-mode rejection ratio (CMRR) has the same meaning for isolation amplifiers as for any other type of differential amplifier: It's the ratio of the applied common-mode input voltage to the equivalent normal-mode input voltage that would induce the same output. In isolators, the source of common-mode response is often the current that flows through the common-mode capacitance appearing in the signal path. Some isolators take advantage of narrow-bandwidth applications such as thermal measurement and provide low-frequency, lowpass filtering to increase common-mode rejection and reduce high-frequency noise.

Corona is a phenomenon that appears as a very small common-mode current. This charge transfer appears only in the presence of air within the insulating medium. Eventually, it leads to a breakdown of the insulating material. An isolator that initially can withstand a common-mode voltage may not be able to withstand it at some time in the future. Many isolators have a specified breakdown voltage with a time limit, meaning that the sustained application of common-mode voltage may cause degradation of the insulation.

Gain accuracy: Isolators, whether they are unity-gain buffers or have gain capability, have an initial gain accuracy, which is the maximum or typical deviation in gain from the ideal value. Normal calibration eliminates this effect on system accuracy.

Gain drift is the change in gain vs temperature. Data sheets usually specify this parameter as a percentage of signal span/°C. Good isolators usually maintain a gain-drift specification of 0.005%/°C or better.

Input isolators take some variable from the field (possibly one in danger of coming in contact with high voltages) and pass it through the isolation barrier to the ground reference. The power to the input isolator is at the same ground potential as the output voltage. Input isolators provide galvanic isolation between the input port and the output and power ports.

Input offset voltage and output offset voltage: Input offset voltage is simply the differential input voltage necessary to provide zero output at any gain.

bandwidth of *10 kHz* at a gain of 1000. Because the AD210's internally isolated supplies power the external ICs, this circuit provides an isolated strain-gauge conditioner, obviating the need for an external dc/dc converter.

A strain gauge, which is often used in weighing applications, is a resistor divider, usually in the form of a bridge, in which the amount of force applied to the gauge controls the division ratio. If the gauge includes bridge-completion resistors, the output of the gauge is the differential voltage between two resistor dividers, one of which varies with force. Two of the signal-conditioning challenges that strain gauges present are the need for a stable, excitation voltage reference to minimize thermal drift, and the need for a low-offset-drift differential amplifier (because of the normal high-gain requirements).

The voltage reference (IC_1) that is powered by the

You usually measure it by shorting the input terminals together and configuring the unit for high gain. The output voltage is then the gain times the input offset voltage plus the output offset voltage. Configuring the isolator for unity gain yields the input offset voltage plus the output offset voltage. You can then solve the two linear relationships to determine the input and output offset voltages. Any circuitry after the gain stage can induce the output offset voltage, making this parameter invariant with gain. Both the input and the output offset voltage drift with temperature. Data sheets normally specify this drift in μV/°C.

Leakage is the common-mode current usually caused by capacitance between the ports. Data sheets usually specify the leakage at some voltage below the breakdown rating. The spec is intended to indicate the maximum common-mode current under certain operating conditions.

Linearity: Measures of linearity vary among manufacturers of isolation amplifiers. Because transformer-based isolators generally exhibit a well-behaved S-shaped nonlinearity, a maximum deviation from a best straight line (BSL) through the transfer function is a particularly useful way of measuring linearity.

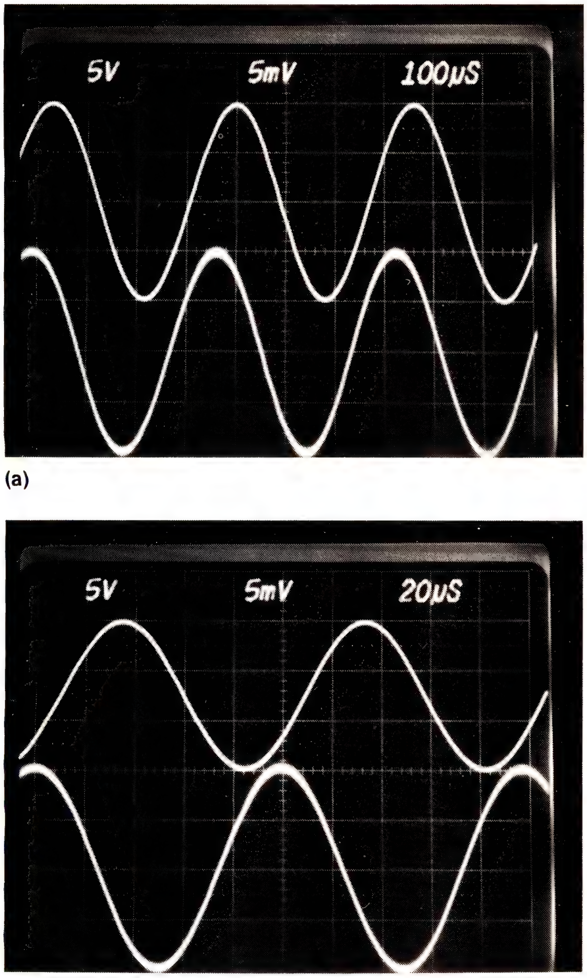
Multichannel beating can occur when you use more than one isolator with an internal clock close to one another: A difference frequency can appear at the output of one or more of the isolators. (This situation can occur only if the difference frequency is within the bandwidth of the device and the circuitry is susceptible to external noise.) To solve the problem, some isolators that are susceptible to beating offer clock-synchronization capability. Other isolators take clock inputs instead of dc power, allowing a single clock to power all the isolators.

Output isolators derive their power from the input port and provide a means of isolating a signal, presumably one routed near a dangerous voltage potential. Output isolators often provide 4- to 20-mA current-loop outputs for use as industrial control signals, and they provide galvanic isolation between the input and power ports and the output port.

Three-port isolators provide galvanic isolation between the input port and power port, the output port and power port, and the input port and output port. Because a majority of isolation-amplifier applications require input isolators, many 3-port isolators offer minimal output-port to power-port breakdown voltage. This type of 3-port isolator derives its power from a source of common-mode potential similar to the output port, while still maintaining galvanic isolation. Such isolation is useful for preventing ground-loop problems between the power supply and the signal, but does not guarantee protection against faults between the output and power ports.

Full 3-port isolators maintain full breakdown-voltage limits between any two ports. You can use this type of isolator as either an input isolator or an output isolator simply by referring the power source to the appropriate port. You can use the isolation of the power port to derive power from some potential other than the input or output, and to provide additional protection against faults in the power supply.

With its internally isolated power supplies, an isolator makes an excellent strain-gauge conditioning circuit without any need for an external dc/dc converter.



(a)

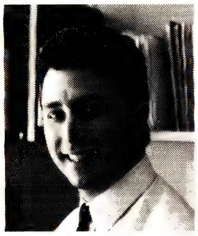
(b)

***Fig 6—These oscilloscope photos** illustrate the ac performance of the tandem amplifier of **Fig 5**. At a gain of 1000, the amplifier has full gain at 2.5 kHz with about 35° of phase shift **(a)**. About half of the phase shift is internal to the AD210. The amplifier's −3-dB point occurs at about 10 kHz **(b)**.*

floating input supply, $+V_{ISS}$, provides a stable excitation voltage reference for a strain-gauge bridge circuit. IC_2 performs an inversion using the bridge-completion resistors of the gauge to improve thermal tracking between the two arms of the bridge. If the gauge is only a half-bridge type, you should use thermal tracking resistors, such as those found on a thin-film network, to create the inversion. The input characteristics of the op amp used to invert the reference are every bit as important as those of the amplifier used to provide the gain. You can adjust the offset of the strain gauge, the tandem amplifier configuration, and the isolator with a trim resistor in one of the two locations indicated by the dashed lines shown in **Fig 5**.

By using an accurate reference inversion to create a bipolar excitation voltage for the bridge, you can reference the output of the strain gauge to ground. Thus, instead of requiring a differential amplifier, you merely require a high-gain, noninverting amplifier with good input characteristics. Connecting IC_3 in tandem with the internal input amplifier of the AD210 produces a gain of 1000. The two 100-pF capacitors stabilize the amplifier pair, yielding a −3-dB bandwidth of 10 kHz at a gain of 1000. The scope photos in **Fig 6** illustrate the transfer characteristics of the dual amplifier. **EDN**

Author's biography



Howard Samuels is a design engineer in the Interface Products Div of Analog Devices (Norwood, MA). His responsibilities include the design of isolators and analog signal-conditioning circuits. Howard, who has been with the company for five years, holds a BSEE from Carnegie-Mellon University. His interests include windsurfing, skiing, and music.

Article Interest Quotient (Circle One)
High 497 Medium 498 Low 499

Terminate bus lines to avoid overshoot and ringing

At high frequencies, the traces on a pc board act as transmission lines, so you may need to terminate them to avoid signal distortion caused by impedance mismatches. The five termination techniques presented here are particularly suitable for use with high-speed CMOS logic, but you can adapt them to suit other logic families as well.

Charles Pace, *Fairchild Semiconductor Corp*

Recent high-speed CMOS logic devices allow low-power CMOS circuits to operate nearly as fast as their ECL or bipolar Schottky counterparts. If you plan to incorporate high-speed CMOS devices in your designs, you'll have to make use of some design and board-layout techniques that are standard practice for high-speed circuits but that are not needed at lower speeds and therefore may be new to you. One of these techniques is line termination. By eliminating impedance mismatches, line termination increases noise immunity, suppresses RFI/EMI, and helps to ensure that signals reach their destinations with minimal distortion.

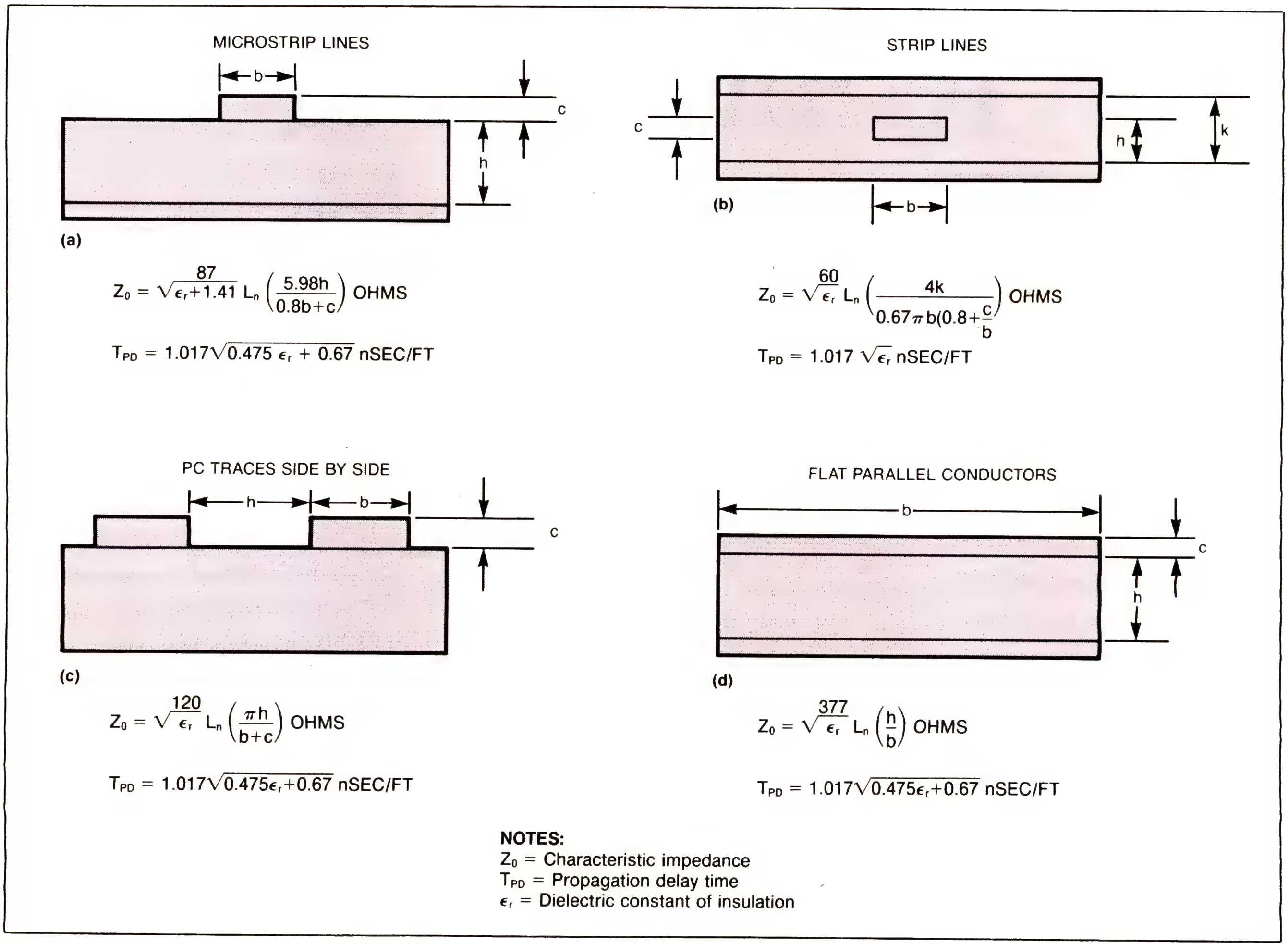
In the following pages, you'll find guidelines that will help you decide whether to terminate traces on your board and, if so, which of five methods (series, parallel, Thevenin, ac, or active termination) best suits your application. The discussions and illustrations relate specifically to devices in the Fact logic family from Fairchild, but you can apply the same principles to designs that use ICs of other high-speed digital-logic families, such as ECL or bipolar Schottky ICs.

Transmission-line effects increase with frequency

Every conductor carrying an ac signal acts as a transmission line, and its distributed resistance, inductance, and capacitance combine to give the conductor what amounts to a characteristic impedance. The value of this impedance depends on physical attributes such as cross-sectional area, the distance between the conductor and other ground or signal conductors, and the dielectric constant of the material between them. Because the characteristic impedance is reactive, its effects increase with frequency. **Fig 1** shows the equations that you can use to calculate, from the line dimensions, the characteristic impedance (Z_0) and propagation delay (T_{PD}) of various types of lines.

Although the resistance, inductance, and capacitance of a pc-board trace are very small, they can cause significant distortion of high-speed digital signals, for two reasons. First, digital pulses are rectangular, which implies that they have very high-frequency harmonics (as high as 200 MHz for a 3-nsec edge rate); the transmission-line effects attenuate these upper harmonics more than they attenuate the fundamental frequency, so the corners of the waveform become rounded and the rise time increases. In effect, the transmission line introduces a time delay between the moment at which the source reaches the peak of the rising edge and the moment at which the destination reaches that same peak.

At high frequencies, all conductors tend to behave as transmission lines; they may need impedance-matching terminations to avoid overshoot and ringing.



(a)

$$Z_0 = \frac{87}{\sqrt{\epsilon_r+1.41}}\, L_n\left(\frac{5.98h}{0.8b+c}\right) \text{ OHMS}$$

$$T_{PD} = 1.017\sqrt{0.475\,\epsilon_r + 0.67} \text{ nSEC/FT}$$

(b)

$$Z_0 = \frac{60}{\sqrt{\epsilon_r}}\, L_n\left(\frac{4k}{0.67\pi b(0.8+\frac{c}{b})}\right) \text{ OHMS}$$

$$T_{PD} = 1.017\sqrt{\epsilon_r} \text{ nSEC/FT}$$

(c)

$$Z_0 = \frac{120}{\sqrt{\epsilon_r}}\, L_n\left(\frac{\pi h}{b+c}\right) \text{ OHMS}$$

$$T_{PD} = 1.017\sqrt{0.475\epsilon_r+0.67} \text{ nSEC/FT}$$

(d)

$$Z_0 = \frac{377}{\sqrt{\epsilon_r}}\, L_n\left(\frac{h}{b}\right) \text{ OHMS}$$

$$T_{PD} = 1.017\sqrt{0.475\epsilon_r+0.67} \text{ nSEC/FT}$$

NOTES:
Z_0 = Characteristic impedance
T_{PD} = Propagation delay time
ϵ_r = Dielectric constant of insulation

Fig 1—You can use these dimensional illustrations *and associated equations to calculate the characteristic impedance (Z_0) and propagation-delay time (T_{PD}) of the four principal conductor configurations that behave as transmission lines.*

Second, gross impedance mismatches (between the transmission line's characteristic impedance and the input or output impedances of devices connected to the line) reflect the signal back and forth on the line. These reflections, which may attenuate or reinforce the signal (depending on the phase relationships), cause overshoot, ringing, excessive radiation of the signal, and other undesirable effects. You can reduce these effects by terminating the line at the end remote from the source, with an impedance that combines with the destination input circuitry to present a load that more closely matches the characteristic impedance of the line. Board traces, for example, usually have characteristic impedances in the range from 50 to 200Ω.

The characteristic impedance of printed-circuit backplane conductors is also in the same range; however, the length of the conductors, or the use of twisted pairs or coaxial cable instead of printed-circuit traces, may greatly change the backplane's characteristic impedance. The number of boards that you plug into the backplane, as well as the slot position you plug a particular board into, can also affect the backplane's impedance.

Terminations introduce tradeoffs

Terminations inevitably cost money, because they require extra components and power. For passive terminations, you may need drivers that deliver more current to the line. For active terminations, the extra power is dissipated by the termination components; some termination circuits may dissipate as much power as (or more power than) the logic circuits do.

Remember that the need for line termination has very little to do with the fabrication technology of the logic devices—the need depends on the edge rate and the amount of delay introduced by line-transmission effects. In general, you can assume that if the calculated propagation delay in any line amounts to one-third or more of the pulse rise time, you need to terminate the line. If the delay is less than one-third of the rise time, you may be able to leave the line unterminated, provided that capacitive coupling between the traces doesn't produce a crosstalk problem and that the input circuits of the destination devices can at least partially suppress ringing.

Power consumption varies

You can see from **Fig 2** that power consumption is greatest (but varies least with frequency) for a 50Ω parallel termination (a resistor connected between the signal line and ground at the destination). Above 16 MHz, series and ac methods of termination cause less power dissipation than do active terminations or unterminated lines. However, when evaluating the suitability of each method within the context of your design, you'll have to consider the relative importance of factors other than power consumption, such as cost, output drive balancing, and switching margins. **Table 1** summarizes the principal characteristics of five termination methods.

Most designers prefer to avoid, whenever possible, the extra complications and cost introduced by terminations. Devices of the Fact family, when driving either bipolar or CMOS devices, will operate reliably with unterminated lines shorter than 8 in., provided that the line delay is less than one-third of the rise time.

The Fact-to-Fact configuration has better noise immunity than do unterminated-line configurations that employ other advanced CMOS devices, and it doesn't increase power consumption, because the devices don't introduce additional dc impedances between the signal line and ground or V_{CC}. This approach is feasible in low-power applications that can tolerate some noise.

Recent modifications to the Fact devices' input structures (the vendor removed the polysilicon input resistor and increased the power-handling capacity of the input diodes) allow the diodes to clamp the input signal to 1V above V_{CC} and 1V below ground. Some mismatch still exists between the characteristic impedance of the signal line and the input impedance of the receiver, but this mismatch is much smaller than that caused by the high-impedance input structures found in older CMOS devices.

You'll find a vivid illustration of transmission-line effects in **Fig 3a.** The solid waveform shows the output of a Fact device that is driving a 3-ft length of coaxial cable with nothing connected to the remote end. The discontinuity at the open end of the cable causes reflections that propagate back and forth over the cable. Some overshoot exists at the driver end, but the driver's output clamping diodes attempt to suppress this overshoot and the subsequent ringing on the line. At the open end of the cable, however, the reflections reinforce each other and nearly double the amount of overshoot.

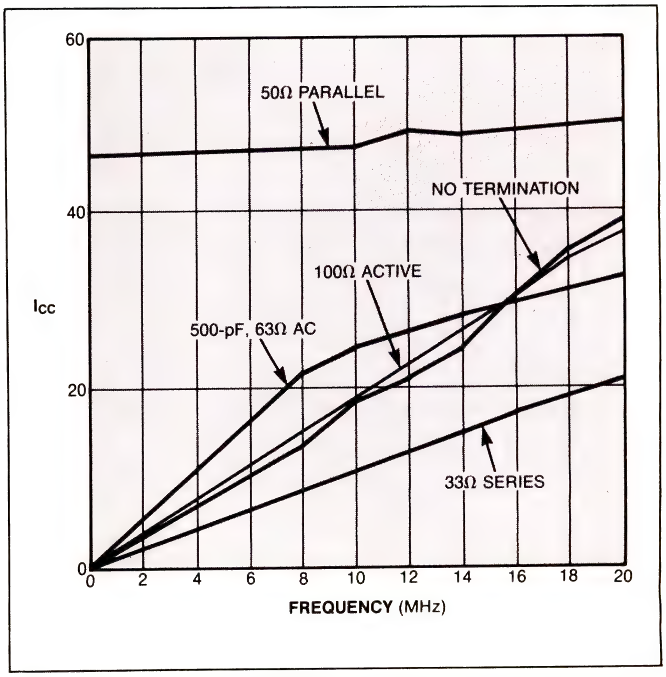


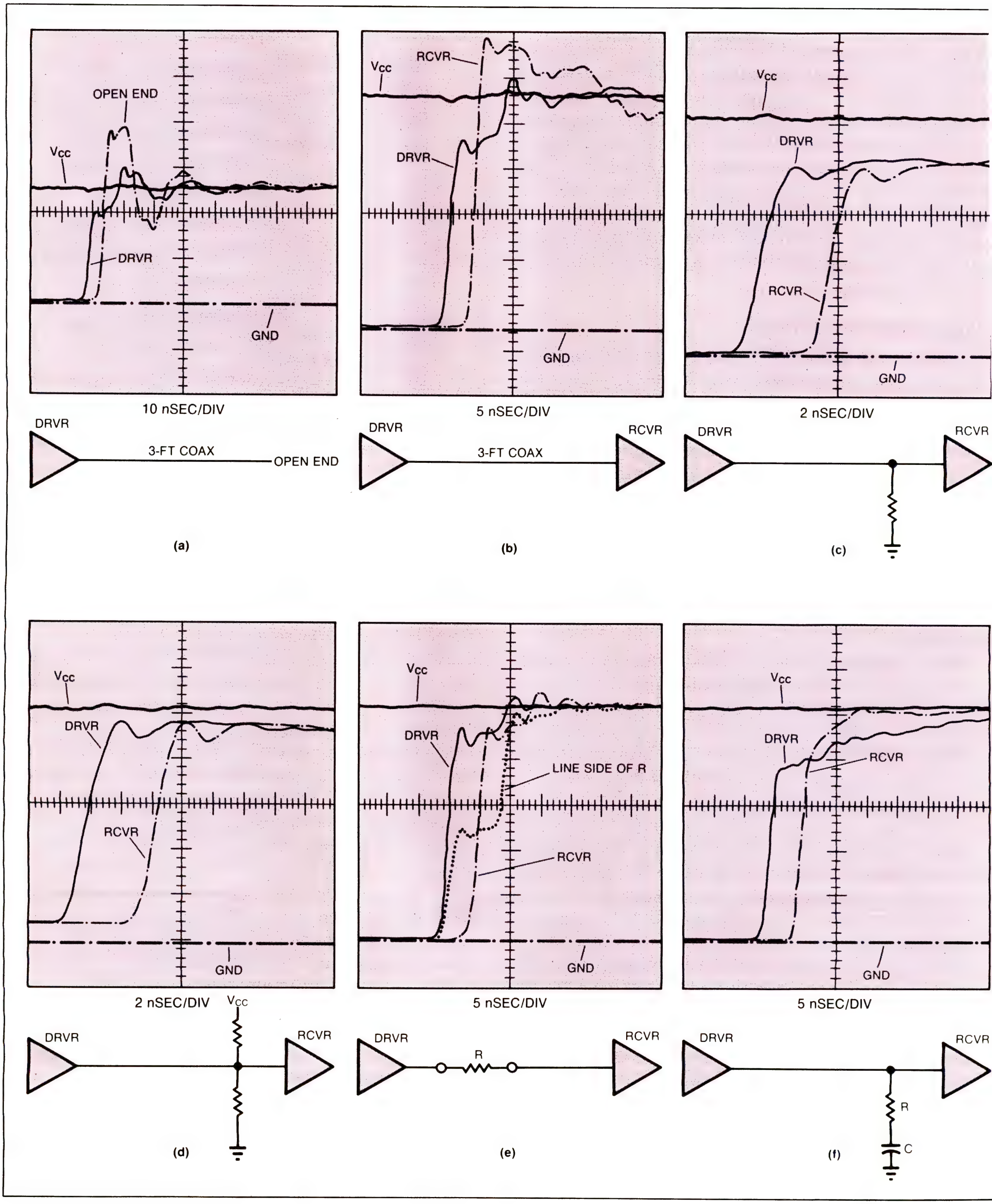
Fig 2—These current-vs-frequency curves *show that series termination dissipates less power than does any other termination method. At low frequencies, unterminated lines are also economical, but they become less satisfactory at frequencies above 16 MHz.*

Fig 3b shows the effect of connecting a Fact device to the formerly open end of the cable. The impedance mismatch between the devices and the cable still causes some overshoot, but the clamping diodes in both the driver's output circuitry and the receiver's input circuitry reduce the overshoot amplitude and quickly suppress the subsequent ringing. These clamping diodes allow the Fact-to-Fact connection to be used reliably on unterminated lines of any length.

Simple parallel terminations

The parallel-termination technique **(Fig 3c)** consists of connecting a resistor from the signal line to ground at the destination end of the line. This technique can

If the propagation delay of a line is one-third or more of the pulse rise time, you should terminate the line to avoid ringing.



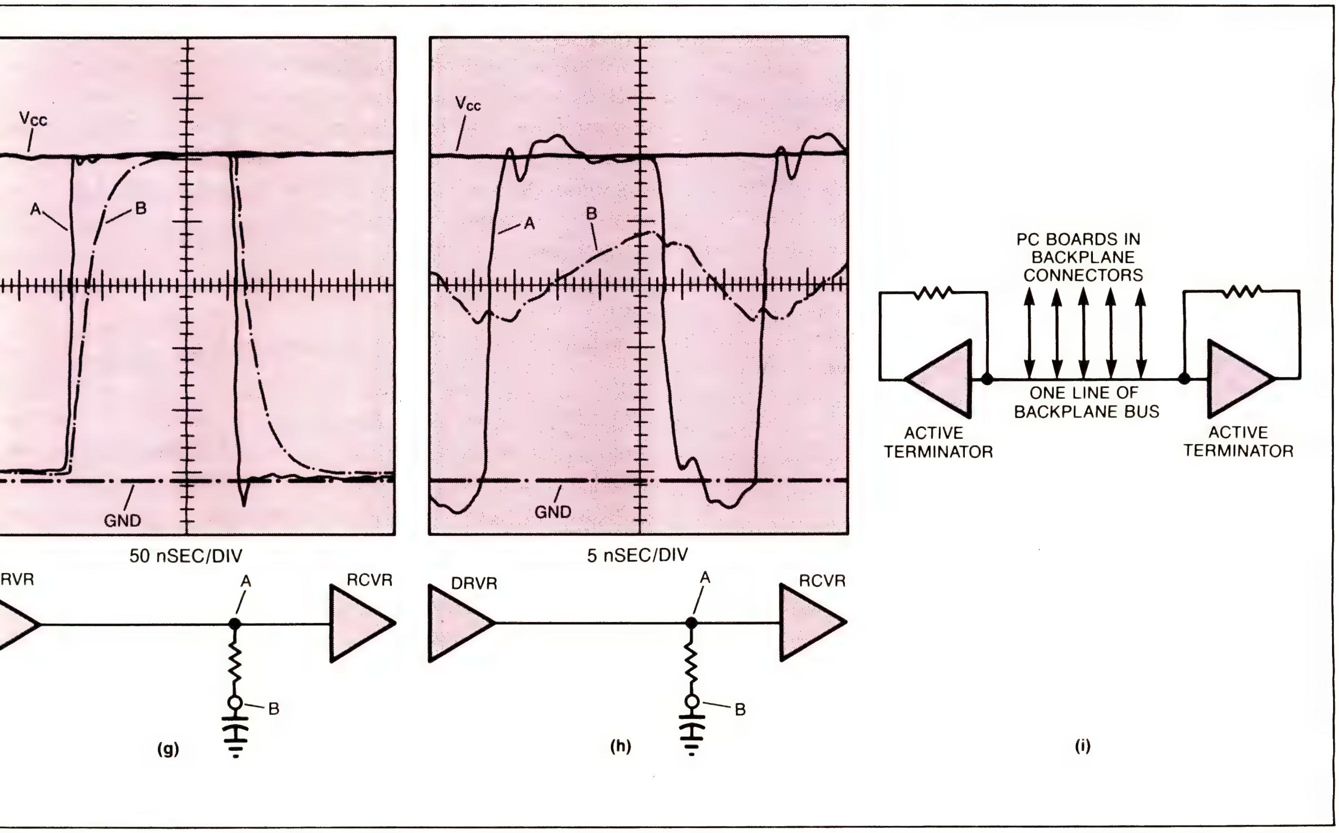


*Fig 3—**These waveforms show the operation of various termination methods.** An open circuit at one end of a transmission line **(a)** produces strong reflections because of the impedance mismatch. By using Fact devices at both ends of the line **(b)**, you can control overshoot and ringing. A parallel termination **(c)** yields a clean waveform at the receiving end but dissipates signal power; the Thevenin method **(d)** is equally clean but consumes even more power. A series termination **(e)** dissipates very little power, and you can tune it easily to match the line. An ac termination **(f)** is effective at low frequencies and provides an ac ground; however, it is frequency-sensitive, as shown by the waveforms measured at 2.5 MHz **(g)** and 25 MHz **(h)**. Active terminations **(i)** can handle long lines and maintain constant signal levels along the entire length of a line.*

dissipate as much as ¼ to ½W, because the resistor value must be in the range from 50 to 200Ω in order to match the characteristic impedance of the line. This extra power dissipation in the terminations is small compared to the total power consumption of bipolar devices. However, because a CMOS system consumes only a few milliwatts of power, and because the terminations may dissipate more power than do the driver or receiver devices they're connected to, the extra drain is significant, especially if the system is battery driven.

The parallel-termination technique is useful mainly in circuits that contain a mixture of bipolar and advanced-CMOS devices, or circuits in which you're replacing bipolar devices with equivalent CMOS devices in order to reduce overall system power consumption. Power consumption is a function of signal duty cycle; connecting the resistor to ground will give the lowest power consumption for low duty cycles, and terminating to V_{CC} will give the lowest power consumption for high duty cycle signals. Terminating to V_{CC} may not allow valid V_{IL} levels to be generated for bipolar inputs. Because the termination can very closely match the characteristic impedance of the line, it eliminates reflections and improves noise immunity. Thus, the waveform at the receiver input is an almost perfect image of the waveform at the driver output **(Fig 3c)**. You can't terminate line impedances of less than 100Ω with their characteristic values because you'd exceed the absolute maximum dc output current limit of 50 m/A.

Thevenin technique suits CMOS/bipolar mix

The Thevenin equivalent-circuit theorem has given rise to a termination technique that smoothes out power-dissipation variations between the high and low portions of the duty cycle. A Thevenin termination consists of one resistor connected from the line to ground and another resistor connected from the line to V_{CC}. Each resistor has a value that is twice the charac-

> *Parallel resistive terminations are the least frequency-sensitive type of termination, but they may dissipate more power than do CMOS logic devices.*

TABLE 1—CMOS TERMINATION COMPARISONS

	TERMINATION TYPE				
FEATURE	PARALLEL	THEVENIN	SERIES	AC	ACTIVE
POWER	HIGH	HIGH	LOW	MEDIUM	MEDIUM
ADDED PARTS	1	2	1	2	1
ADDS DELAY	NO	NO	YES	NO	NO
RESISTOR VALUE	Z_0	$2 \times Z_0$	$Z_0 - Z_{OUT}$	Z_0	$2 \times Z_0$
CAPACITOR VALUE	0	0	0	200 pF TO 500 pF	0

teristic impedance of the line, so the combination closely matches the line impedance.

If no logic devices were present, the line would sit at a potential halfway between V_{CC} and ground. When a logic device is driving the line, part of the required current is supplied by the resistors, so that the driver can supply less current than it would have to deliver to a parallel termination. You can adjust the resistor values to bias the line toward V_{CC} or toward ground, but the normal procedure is to make them equal to provide balanced operation. The Thevenin termination yields good overshoot suppression and noise immunity **(Fig 3d).**

The power dissipation of Thevenin terminations makes them best suited to bipolar or mixed bipolar/CMOS systems. In all-CMOS systems, this termination method may cause problems for several reasons. First, CMOS input circuits have very high impedances to ground and V_{CC}, and their switching threshold is 50% of the supply voltage. Balancing the input signal around the 50% threshold causes greater levels of power dissipation within the devices. Second, if the source end of a Thevenin-terminated line becomes disconnected from the signal source, the termination pulls the input level toward the threshold, thereby causing the receiver to dissipate even more power, because of the soft-turn-on characteristic of the input transistors. Additionally, multiple input crossings may occur, creating output oscillation or other anomalies. Finally, the power dissipated in the termination resistors may be unacceptably high in relation to the total power consumption of all the CMOS devices on the board.

Most makers of advanced CMOS devices recommend series termination for CMOS-CMOS connections, because this technique introduces no extra impedance from signal line to ground. A series termination consists of a resistor connected between the driver-output terminal and the line; the resistor value should be equal to the characteristic impedance of the line minus the output impedance of the driver. For circuits using Fact devices, the series termination increases the impedance presented to the output drivers; therefore, the drivers dissipate less power than they would without the termination.

The waveforms for series termination **(Fig 3e)** are more complex than those for the previously described techniques. The solid waveform represents the waveform at the driver's output terminal. The termination resistor and the characteristic impedance of the line combine to form a voltage divider that attenuates the transmitted signal (the dotted waveform). At the receiving end, however, the mismatch between the line impedance and the high impedance of the input circuitry causes self-reinforcing reflections that restore the received signal (the dashed waveform) to the level of the source. The clamping diodes of the Fact devices' input circuitry prevent excessive overshoot and ringing.

You'll note a distinct step in the (dotted) waveform that appears at the junction of the terminating resistor and the line; the signal at this point does not reach its full amplitude until it's reinforced by a reflection from the far end of the line. You may need to adjust the resistor value so that the half-amplitude signal is either well above or below the switching threshold of any receiving device located close to the driver. To ensure proper input levels at these receivers, you should take into account the delay for reinforcing reflections to arrive (twice the propagation delay of the line).

The great advantage of the series technique (apart from its reduction of power consumption) is its flexibility; you can adjust the received signal amplitude to match the switching threshold of the receiver merely by changing the value of the terminating resistor. For this reason, the technique is particularly useful if you need to interconnect the logic devices with long lines.

AC termination provides an ac ground

Most ac terminations consist of a resistor and a capacitor connected in series from the line to ground. Their action is similar to that of parallel terminations, except that in ac terminations the capacitor blocks the dc component of the signal (and thereby reduces power dissipation), while still providing an ac ground for the impedance-matching resistor. AC terminations are convenient for designs that can't tolerate the high power

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AC terminations are convenient for designs that can't tolerate high power dissipation or delays.

dissipation of a parallel termination or the delays created by a series termination.

The waveforms for an ac termination **(Fig 3f)** show that, after the initial edge of the pulse, the driver signal rises slowly as the capacitor charges toward V_{CC}. The effect is less pronounced in the received signal.

To calculate the optimum RC time constant of the termination network, start with a resistor whose value is equal to or slightly larger than the characteristic line impedance. Take care when determining the value of the capacitor. If the RC time constant is too small, the RC circuit will act as an edge generator and create over- and undershoots. Increasing the capacitor value reduces the over- and undershoot, but increases power consumption. As a general rule, the RC time constant should be greater than twice the line delay.

When you calculate the power dissipation of an ac termination, remember that the power dissipation is a function of frequency. Remember, too, that the line itself possesses some distributed capacitance; you'll have to add the value of this capacitance to the value of the capacitor in the RC network.

At low frequencies (relative to the time constant), the network capacitor completely charges and completely discharges during each cycle of the input signal **(Fig 3g, trace B)**. The compensated signal that appears at the top of the resistor and drives the CMOS receiver is very square, with a small amount of undershoot on the trailing edge **(Fig 3g, trace A)**.

At high frequencies (relative to the time constant), the capacitor doesn't have time to fully charge or fully discharge in each cycle, so it begins to integrate the waveform **(Fig 3h, trace B)**. Because the ac termination is so frequency-dependent, the duty cycle will also affect its operation. A narrow input pulse with a low repetition rate will affect the charging and discharging of the capacitor in the same way as will a pulse with a higher repetition rate but a longer duty cycle. In either case, the receiver will perceive only the square (compensated) signal and will switch as expected, with no adverse effects from the rounding or integration of the waveform as measured across the capacitor.

Active terminations suit backplanes

Active terminations consist of a resistor connected between the input and output of a buffer/driver **(Fig 3i)**. They can be somewhat more costly than other types of termination if the buffer is not available; also, active terminations do not produce signals as clean as other termination schemes. They can handle larger impedance variations, however, and this characteristic is valuable when you're driving a backplane with 3-state devices. It's common to provide active terminations at both ends of a bus, because doing so helps to maintain uniform drive levels along the entire length of the bus, while at the same time reducing crosstalk (between adjacent traces) and ringing. Be sure, however, to use noninverting buffers as the terminating devices: If you connect a resistor between the output and input of an inverting buffer, you create a dc path that will draw more power from the driving devices. **EDN**

Author's biography

Charles Pace is digital-application manager at Fairchild Semiconductor Corp (South Portland, ME), where he's responsible for evaluating new-product proposals, preparing application notes, presenting demonstrations at customer sites, and designing demonstration boards. He holds BSEE and BSES degrees from the University of Notre Dame. Before joining Fairchild, Charlie was an applications engineer in the Programmable Products Div of Texas Instruments. He's a member of the volunteer fire department in his home town, and in his spare time he enjoys sailing, skiing, swimming, golf, and softball.

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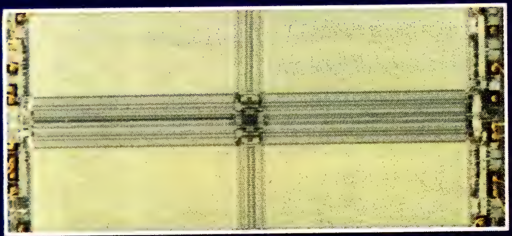
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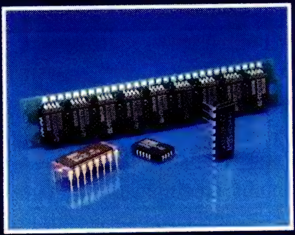
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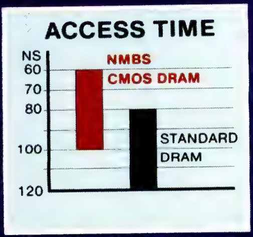

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CIRCLE NO 151

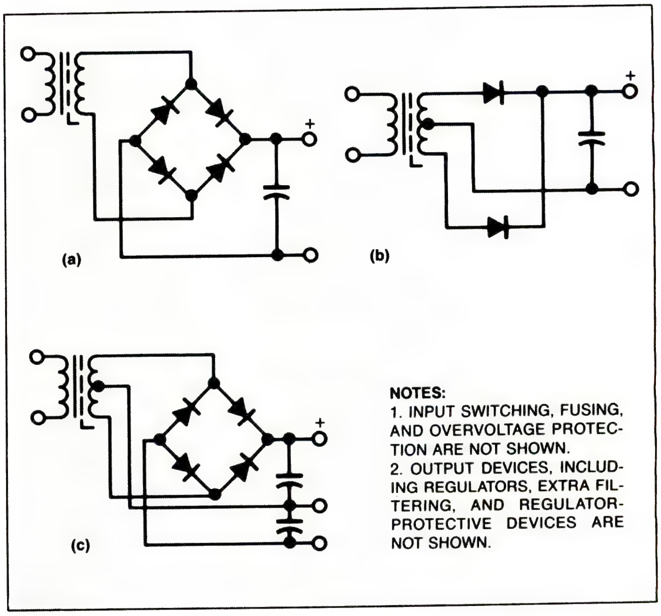
Basic program simplifies design of linear power supplies

The Basic program presented here can spare you a lot of the math involved in designing linear power supplies. The program prompts you for design specs and then generates the parameters for a workable design.

George Sayer, *Consulting Engineer*

Although the techniques for linear-power-supply design have gradually improved over the years, they still have one chief shortcoming—they require you to perform major mathematical manipulations for each supply design or design change. The Basic program presented here can spare you the math. It asks you simple questions and then generates the parameters for a supply design. The program allows you to use standard off-the-shelf components, so there's no need for you to perform any mathematical manipulations at all.

Your first task in designing a power supply, as in any design, is to establish your objectives. For example, you want the supply to function properly under all operating conditions. Such conditions will include high and low line voltages as well as varying temperatures. You need to keep in mind that the transformer's electrical resistance and core losses will generate heat and that the regulator, the rectifiers, the surge resistor (if you use one), and the enclosure will also contribute to the heat rise.



NOTES:
1. INPUT SWITCHING, FUSING, AND OVERVOLTAGE PROTECTION ARE NOT SHOWN.
2. OUTPUT DEVICES, INCLUDING REGULATORS, EXTRA FILTERING, AND REGULATOR-PROTECTIVE DEVICES ARE NOT SHOWN.

***Fig 1—The power-supply-design program can help you design** full-wave-bridge (FWB) **(a)** and full-wave-center-tap (FWCT) **(b)** supplies, and you can adapt the program's FWCT analysis to a dual complementary supply (DCS) **(c)**.*

Besides being aware of electrical and temperature considerations, you need to take into account mechanical considerations (such as space for the supply) and shock and vibration problems. Finally, you must consider factors such as troubleshooting, the cost and ease of obtaining parts, the availability of alternate sources for

The program analyzes supply operation under high and low line-voltage conditions while the transformer is at ambient and at peak temperatures.

parts, and the parts' reliability and compliance with safety standards.

The power-supply design program in **Listing 1** (pg 241) analyzes supply operation under high and low line-voltage conditions while the transformer is at ambient and at peak temperatures. Because it specifies off-the-shelf components, the program also partially solves the problems of parts availability and alternate sources.

The program compensates for regulation increase with temperature and for high and low line voltages. It is written in GW-Basic, version 2.02, which can run on many microprocessors. Its performance relies on two assumptions—the transformer regulation spec is a room-temperature figure (no warmup), and the leakage inductance in the transformer and series loss in the filter capacitor are negligible.

You can use the program in **Listing 1** to design full-wave-bridge (FWB) and full-wave-center-tap (FWCT) supplies, and you can adapt the program's FWCT analysis to a dual complementary supply (DCS) (**Fig 1**). The program uses the diode count, D, to compensate for differences between the FWCT and FWB circuits. K, the ratio of the transformer output resistance in the actual circuit to the output resistance in the manufacturer's test circuit, compensates for output-resistance modifications in the FWCT circuit.

The program begins by asking you to enter the transformer's nominal input voltage specification (110V, 115V, 117V, 120V, 230V, etc). Next, you define worst-case high-line and low-line voltages. Then you enter the line frequency. If your supply is intended for

Glossary of program variables

The following is a list of the variables used in the power-supply design program in **Listing 1.**

CMIN: Min permissible filter capacity (program derived)

D: Number of rectifiers (2 for FWCT designs; 4 for FWB designs)

DBMNR: The regulator's min ripple attenuation (manufacturer's data)

FRQ: Nominal line frequency (usually 50 or 60 Hz.)

HACC: Half-angle of current flow at ambient temperature (derived from program)

HACH: Half-angle of current flow at full temperature rise (derived from program)

ICRMS: RMS capacitor current (derived from program)

IDC: Full load current required by the application

IDCL: Regulator current limit specification (derived from program)

IDPR: Repetitive peak rectifier current (derived from program)

IDRMS: RMS value of diode current (derived from program)

IINRSH: Max inrush current (derived from program)

IINRSHA: Max inrush current (rounded) (derived from program)

I1N(etc): Points on rectifier curves

IS1: Suggested current of transformer's secondary winding (derived from program)

ITC: RMS transformer current at ambient temperature (derived from program)

ITH: RMS transformer current at full temperature rise (derived from program)

ITHA: Adjusted RMS transformer current at full temperature rise (derived from program)

ITRTD: Actual rated current used in program for transformer's secondary windings (derived from program)

ITRTD1: Actual rated current for transformer's secondary winding (manufacturer's data)

ITRDT2: Adjusted ITRTD1 (derived from program)

I1X(etc): Points on rectifier curves

K: Ratio of the transformer output resistance used to the output resistance in the configuration the manufacturer specifies (derived from program)

N: Number of passes through a subroutine in the program

NRGNC: Estimated new transformer regulation to lower inrush current

PD: Individual rectifier power dissipation (derived from program)

PRGMX: Max regulator power dissipation (derived from program)

PRSRGP: Power dissipated in surge resistor (derived from program)

PTPRS: Predicted transformer temperature rise (derived from program)

RDFA: Rectifier forward resistance (derived from program)

RECT1: Rectifier constant (derived from program)

RECT2: Rectifier constant (derived from program)

RECT3: Rectifier constant (derived from program) an international market, you must evaluate the design at both 50 and 60 Hz. To proceed, you then enter the required full-load current value.

At this point, the program determines the regulator's minimum current limit. Using data-sheet information, you select a trial regulator and enter its maximum and minimum output voltages, its dropout voltage at the maximum expected load current (I_{DC}), and its minimum ripple attenuation. Next, you enter the allowable peak-to-peak ripple voltage (in millivolts) at the regulator output.

The program then displays the maximum filter-output ripple on the monitor; if the ripple is more than 20% of the output voltage, the program requests that you enter a lower output ripple voltage. The program's math requires that the ripple be less than 20%, a reasonable figure for optimum supply performance.

The program then asks you to define the type of rectification (FWB or FWCT) by entering either 4 or 2, respectively. These numbers establish the rectifier count. The program then asks if you'll be using 1N4001 diodes. If the answer is yes, the program automatically enters the values for RECT1 through RECT4. If the answer is no, the program branches to a routine that asks you to specify a rectifier type and to enter some points on the rectifier's maximum and minimum current-vs-voltage curves. The program then determines the values of RECT1 through RECT4 and returns from the routine.

At this point, the program approximates the transformer's output-voltage requirements, and it inquires whether the transformer will have one or two secon-

RECT4: Rectifier constant (derived from program)
RGNC: Transformer regulation at ambient temperature (derived from program)
RGNC2: Transformer regulation at ambient temperature (manufacturer's data)
RGNH: Transformer regulation at TPRS (derived from program)
RIP: Max allowed filter output ripple (derived from program)
RIPA: RIP rounded to two decimal places (derived from program)
RIPO: Allowable regulator p-p ripple output (derived from program)
RIPOM: Allowable regulator p-p ripple output in millivolts
RSRG: Surge resistor in transformer secondary (derived from program)
RSRGP: RSRG moved to transformer primary (derived from program)
S: Number of transformer secondaries (manufacturer's data)
TPRS: Transformer temperature rise (manufacturer's data)
VDFA: Effective rectifier voltage drop (derived from program)
VDMN: Min rectifier voltage drop with IDPR (derived from program)
VDMNR: Min allowed rectifier reverse voltage (derived from program)
VDMX: Max rectifier voltage drop with IDPR (derived from program)
VFLMN: Min full-load filter output voltage (derived from program)
VFLMX: Max full-load filter output voltage (derived from program)
VHL: Highest line voltage expected in the application
VLL: Lowest line voltage expected in the application
V1N(etc): Points on rectifier curves
VNL: Nominal transformer input voltage (manufacturer's data)
VNLMX: Max no-load filter output voltage (derived from program)
VR: Max regulator dropout voltage at I_{DC} (manufacturer's data)
VROM: Max regulator output voltage (manufacturer's data)
VTR: Voltage of transformer's secondary winding (obtained from a heuristic formula, derived from program)
VTRS: Suggested voltage for transformer's secondary winding (derived from program)
VTRTDC: Rated voltage used in program for transformer's secondary winding (derived from program)
VTRTDC1: Actual rated voltage of transformer's secondary winding (manufacturer's data)
VTRTDC2: Rated voltage of transformer's secondary winding at ambient temperature (derived from program)
VTRTDH: Rated voltage of transformer's secondary winding at full temperature rise (derived from program)
V1X(etc): Points on rectifier curves
XC: Variable used to determine HACC (derived from program)
XH: Variable used to determine HACH (derived from program)

You can use the program to design full-wave-bridge (FWB), full-wave-center-tap (FWCT), and DCS or center-tapped-bridge supplies.

dary windings (power-supply transformers usually have two secondary windings). After a few more internal calculations, the program displays the suggested voltage and current for the transformer's secondary windings and asks you to choose a transformer from manufacturers' catalogs. The program then asks for the actual voltage and current ratings of the selected part's secondary windings. The program assumes that when you choose from a list of transformers with two secondary windings (S=2), the manufacturer's test circuit has the two secondaries in parallel.

For further computations, the program adjusts the voltage and current values according to the number of secondary windings and rectifiers. The program then requests the transformer's temperature rise at full load and the transformer's regulation. After receiving that information, the program computes many of the required output values, including the maximum inrush current. If the inrush current is too high for the selected rectifiers, the program requests a higher value of regulation and determines a corresponding surge-resistor value. The program then recomputes all the main output values and displays a new inrush current. You repeat this sequence until you have an acceptable inrush-current value.

The program then asks you to ready the printer. It prints your inputs first (in the order entered) and then prints the names of the components. Next, it prints all the output values. If VFLMN (the minimum full-load filter output voltage) is less than VROM+VR (the

```
INPUTS
VNL= 115        VHL= 130        VLL= 95         FRQ= 60         IDC= .5
VROM= 5.2       VROMN= 4.8      VR= 2           DBMNR= 62       RIPO= .0004
DIODES= 2       SCNDRS.= 2      VTRTDC1= 8      ITRTD1= 1.6     TPRS= 46
RGNC2= .21      REGLTR= LM7805C                 RECTFRS=  1N4001 SERIES DIODES
XFMR= TRIAD-UTRAD FS16-800
OUTPUTS
TRANSFORMER CURRENT AT REQUIRED FULL LOAD, AC AMPS = .82
MAXIMUM ALLOWABLE CURRENT OUTPUT (WHEN LOAD INCREASED SO THAT
TRANSFORMER LOAD = LOAD AT FULL TEMP. RISE), DC AMPS =  .86
MINIMUM CAPACITY OF FILTER CAPACITOR, MICROFARADS =  4800
RMS CAPACITOR CURRENT, AMPS =  .68
MAX. NO LOAD FILTER OUTPUT VOLTAGE, VOLTS =  15.5
MAX. FULL LOAD FILTER OUTPUT VOLTAGE, VOLTS =  11.7
MIN. FULL LOAD FILTER OUTPUT VOLTAGE, VOLTS =  7.3
MAX. REGULATOR POWER DISSIPATION, WATTS = 3.3
INDIVIDUAL RECTIFIER POWER DISSIPATION, WATTS = .27
MINIMUM RECTIFIER REVERSE VOLTAGE, VOLTS = 31
MAX. INRUSH CURRENT, AMPS = 9
REPETITIVE PEAK RECTIFIER CURRENT, AMPS = 1.8
SURGE RESISTOR (IF IN XFRMR PRIMARY), OHMS = 0
POWER DISSIPATED IN SURGE RESISTOR, WATTS = 0
PREDICTED TRANSFORMER TEMPERATURE RISE, DEG C = 31
```

(a)

```
INPUTS
VNL= 115        VHL= 130        VLL= 95         FRQ= 60         IDC= .5
VROM= 5.2       VROMN= 4.8      VR= 2           DBMNR= 62       RIPO= .0004
DIODES= 4       SCNDRS.= 2      VTRTDC1= 8      ITRTD1= 1.6     TPRS= 46
RGNC2= .21      REGLTR= LM7805C                 RECTFRS=  1N4001 SERIES DIODES
XFMR= TRIAD-UTRAD FS16-800
OUTPUTS
TRANSFORMER CURRENT AT REQUIRED FULL LOAD, AC AMPS = .88
MAXIMUM ALLOWABLE CURRENT OUTPUT (WHEN LOAD INCREASED SO THAT
TRANSFORMER LOAD = LOAD AT FULL TEMP. RISE), DC AMPS =  1.01
MINIMUM CAPACITY OF FILTER CAPACITOR, MICROFARADS =  5300
RMS CAPACITOR CURRENT, AMPS =  .76
MAX. NO LOAD FILTER OUTPUT VOLTAGE, VOLTS =  15.5
MAX. FULL LOAD FILTER OUTPUT VOLTAGE, VOLTS =  11.6
MIN. FULL LOAD FILTER OUTPUT VOLTAGE, VOLTS =  6.7
VFLMN < (VROM+VR). THIS REQUIRES EITHER LESS ALLOWABLE
OUTPUT RIPPLE OR HIGHER TRANSFORMER VOLTAGE, OR BOTH.
```

(b)

Fig 2—These program outputs give the parameters for a successful design *of a 5V/0.5A supply. The output in* ***(a)*** *gives the values for an FWCT-type design. The output for the FWB design* ***(b)*** *reports that the extra diodes cause low regulator input voltage under low line-voltage conditions.*

maximum regulator output voltage plus the maximum regulator dropout voltage at I_{DC}), the program generates the message: "VFLMN<(VROM+VR); this requires either less allowable output ripple or higher transformer voltage, or both." You must then check each of the output values against the component specifications to make sure you've chosen acceptable components. **Fig 2** gives samples of the program's output for a 5V/0.5A supply.

In addition to helping you design FWCT and FWB circuits, the program can accommodate a third circuit—the dual complementary supply (DCS), also known as the center-tapped bridge. The DCS is a popular circuit for applications that require positive and negative voltages. The most useful design approach to the DCS is to program as if you have two FWCT supplies in parallel. You simply add the load currents and then analyze the supply as a single FWCT circuit. You should then proportion the capacitor sizes according to the load current. For example, if the program provides 1000 µF and one supply current is 0.1A and the other is 0.3A, the corresponding capacitor sizes should be 250 µF and 750 µF. The capacitor voltages and ripple voltages do not change. The regulator power dissipations will be proportional to the load current and should be divided as the capacitor values are. **EDN**

References

1. Lieders, A, "Single-phase rectifier circuits with CR filters, Part 1—Theory," *Electronic Components and Applications*, Vol 1, No 3, May 1979, pgs 163-165.

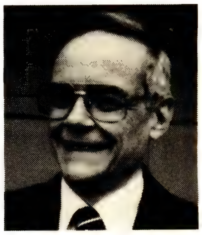
2. Lieders, A, "Single-phase rectifier circuits with CR filters, Part 2—Design procedures," *Electronic Components and Applications*, Vol 1, No 4, August 1979, pgs 216-230.

3. Richards, J C S, "Simplified design of dc power supplies," *Wireless World*, Vol 87, August 1981, pgs 35-37. (See also Vol 88, March 1982, pgs 67-68.)

4. Schade, O H, "Analysis of rectifier operation," *Proceedings of the Institute of Radio Engineers*, Vol 31, No 7, July 1943, pgs 341-361.

You can obtain formula derivations not found in the above references directly from the author at 858 NW 8th Ave Dr, Hillsboro, OR 97124.

Author's biography



George Sayer is a consulting engineer in Hillsboro, OR; he specializes in power-supply design. George holds AB and BSEE degrees from Columbia University and an MS in applied math from Adelphi University. He was previously employed by Grumman, Western Electric, and a number of other companies. George is a licensed professional engineer in Oregon and is also a part-time stockbroker.

Article Interest Quotient (Circle One)
High 482 Medium 483 Low 484

LISTING 1

```
10 PRINT "*****************************************"
20 PRINT "    LINEAR FULL WAVE REGULATED POWER"
30 PRINT "    SUPPLY DESIGN WITH OFF-THE-SHELF"
40 PRINT "    COMPONENTS, FOR USE WITH GW-BASIC"
50 PRINT "       BY GEORGE SAYER - 08-25-86"
60 PRINT "*****************************************":PRINT
70 INPUT "NOMINAL TRANSFORMER INPUT VOLTAGE (EG. 115,120,230), VOLTS"; VNL
80 INPUT "HI-LINE VOLTAGE (EG. 130, 250), VOLTS"; VHL
90 INPUT "LO-LINE VOLTAGE (EG. 95, 190), VOLTS"; VLL:PRINT
100 INPUT "LINE FREQUENCY (EG. 50, 60)";FRQ:PRINT
110 INPUT "REQUIRED FULL LOAD CURRENT, AMPS "; IDC:PRINT
120 IDCL=IDC/.65:IDCL=IDCL*100:IDCL=CINT(IDCL):IDCL=IDCL/100
130 PRINT "CHOOSE REGULATOR WITH CURRENT LIMITING (AMPS)=";IDCL;"OR GREATER":PRI
NT:INPUT "REGULATOR CHOSEN ";RG$:PRINT
140 INPUT "MAX. REGULATOR OUTPUT VOLTAGE (NOMINAL + TOLERANCE), VOLTS "; VROM
150 INPUT "MIN. REGULATOR OUTPUT VOLTAGE (NOMINAL - TOLERANCE), VOLTS "; VROMN
160 INPUT "MAX. REGULATOR DROPOUT VOLTAGE AT MAX. LOAD, VOLTS"; VR:PRINT
170 INPUT "REGULATOR'S MIN. RIPPLE ATTENUATION, DB "; DBMNR
180 INPUT "ALLOWABLE P-P RIPPLE AT REGULATOR OUTPUT, MILLIVOLTS "; RIPOM
190 RIPO=RIPOM/1000
200 RIP = RIPO*(10^(DBMNR/20))
```

Listing continued on pg 242

LISTING 1 *(Continued)*

```
210 RIPA=RIP*100:RIPA=CINT(RIPA):RIPA=RIPA/100
220 PRINT "MAX. FILTER OUTPUT RIPPLE, VOLTS P-P = ";RIPA:PRINT
230 IF RIP>.2*(VROM+VR) THEN 240 ELSE 270
240 PRINT "RIPPLE OVER 20% REGULATOR MIN. INPUT VOLTAGE."
250 PRINT "REDUCE ALLOWABLE P-P RIPPLE AT REGULATOR OUTPUT."
260 GOTO 180
270 PRINT "DECIDE ON FWB OR FWCT CONNECTION. (SUGGEST FWB WITH > 9.5 VOLT"
280 PRINT "OUTPUT AND FWCT UNDER THAT.)":PRINT
290 INPUT "NUMBER OF INDIVIDUAL SILICON RECTIFIERS (4 FOR FWB AND 2 FOR FWCT)";
D
300 IF (D<>4) AND (D<>2) THEN 290
302 PRINT: INPUT "DO YOU INTEND TO USE 1N4001 SERIES RECTIFIERS, YES OR NO";R$
304 IF (R$<>"YES") AND (R$<>"NO") THEN 302
306 IF (R$="YES") THEN 308 ELSE 1430
308 RECT1=.0695:RECT2=8650000!:RECT3=.0695:RECT4=99900!:DX$=" 1N4001 SERIES DIOD
ES"
310 VTR = VNL/VLL/1.414/.9*(VROM+VR+RIP+D/1.6):PRINT
320 INPUT "WILL TRANSFORMER HAVE ONE OR TWO SECONDARIES (1 FOR ONE, 2 FOR TWO) "
;S
330 IF (S<>1) AND (S<>2) THEN 320
340 RSRG = 0
350 IF S=1 AND D=2 THEN 360 ELSE 370
360 IS1=IDC:VTRS=2*VTR:GOTO 390
370 IS1=2*IDC:VTRS=VTR
390 VTRS=CINT(VTRS)
400 PRINT "SUGGESTED TRANSFORMER SECONDARY VOLTAGE = "; VTRS:PRINT
410 PRINT "SUGGESTED TRANSFMR. SECNDRY. CURRENT (TOTAL IF 2 SECONDARIES)= "; IS1
420 PRINT:PRINT "CHOOSE A TRANSFORMER FROM MANUFACTURER'S CATALOGS WITH "; S
430 PRINT "SECONDARIES AND CLOSE TO SUGGESTED SECNDRY. CURRENT AND VOLTAGE":INPU
T "TRANSFORMER CHOSEN "; T$
440 PRINT:INPUT "ACTUAL TRANSFORMER RATED SECONDARY VOLTAGE, VOLTS"; VTRTDC1
450 IF S=1 AND D=2 THEN VTRTDC2 = .5*VTRTDC1 ELSE VTRTDC2 = VTRTDC1:PRINT
460 INPUT "ACTUAL TRANSFORMER RATED SECONDARY CURRENT (TOTAL IF 2 SECS.), AMPS";
 ITRTD1:PRINT
470 IF S=1 AND D=2 THEN ITRTD2=2*ITRTD1 ELSE ITRTD2=ITRTD1
480 INPUT "TRNSFMR. TEMP. RISE, DEG. C"; TPRS: PRINT
490 INPUT "TRNSFMR. RATED REGULATION (IF 2 SECS., WHEN IN PARALLEL), COLD, DECIM
AL"; RGNC2
500 IF S=2 AND D=2 THEN K=1.5 ELSE K=1: IF S=1 AND D=2 THEN K=.375
510 N=0: RGNC=RGNC2:VTRTDC=VTRTDC2:ITRTD=ITRTD2
520 RGNH = 1/((1+1/RGNC)/(.00393*TPRS+1)-1)
530 VTRTDH = VTRTDC*(RGNC+1)/(RGNH+1)
540 XC = K*RGNC/(RGNC+1)*IDC/ITRTD
550 XH = K*RGNH/(RGNH+1)*IDC/ITRTD
560 HACC = 1.494*(XC^.333)+.111*XC
570 HACH = 1.494*(XH^.333)+.111*XH
580 ITC = 1.37*IPC/(HACC^.5)
590 ITH = 1.37*IDC/(HACH^.5)
600 CMIN = IDC*(.5-HACC/3.1416)/(FRQ*RIP)
610 ICRMS = ((ITC^2)-(IDC^2))^.5
620 VNLMX = 1.414*VHL/VNL*VTRTDC*(RGNC+1)
630 IDPR = 2.36*IDC/HACC
640 VDMX= RECT1*LOG(RECT2*IDPR)
650 VDMN= RECT3*LOG(RECT4*IDPR)
660 VDFA = RECT1*(2*LOG(RECT2*1.5*IDC)-LOG(RECT2*3*IDC))
670 RDFA = .667*RECT1*(LOG(RECT2*3*IDC)-LOG(RECT2*1.5*IDC))/IDC
680 IDRMS = .5*(ICRMS^2+IDC^2)^.5
690 VFLMX = VNLMX*COS(HACC)-VDMN*D/2+RIP/2
700 VFLMN = VLL/VHL*VNLMX*COS(HACH)-VDMX*D/2-RIP/2
710 PRGMX = (VFLMX-RIP/2-VROMN)*IDC
720 PD = VDFA*IDC/2+IDRMS^2*RDFA
730 IINRSH = (VNLMX-D/2*VDMN)/(RGNC*K*VTRTDC/ITRTD+RDFA*D/2)
740 IDCMAX = .87/K^.4*((RGNH/(RGNH+1))^.2)*ITRTD:PRINT
750 IINRSHA=CINT(IINRSH)
760 PRINT "MAX. INRUSH CURRENT, AMPS = "; IINRSHA
770 INPUT "CAN RECTIFIERS HANDLE THIS INRUSH CURRENT (YES OR NO)";A$
780 IF (A$<>"YES") AND (A$<>"NO") THEN 770
790 IF (A$="YES") THEN 930 ELSE 800
800 N=N+1
810 IF N=2 THEN 820 ELSE 850
820 PRINT:PRINT "NOTE: PROGRAM RETURNS TO ORIGINAL CONDITION OF NO"
830 PRINT "SURGE RESISTOR. LAST NEW REGULATION WAS"; NRGNC:PRINT
840 GOTO 510
```

Listing continued on pg 244

PHILIPS

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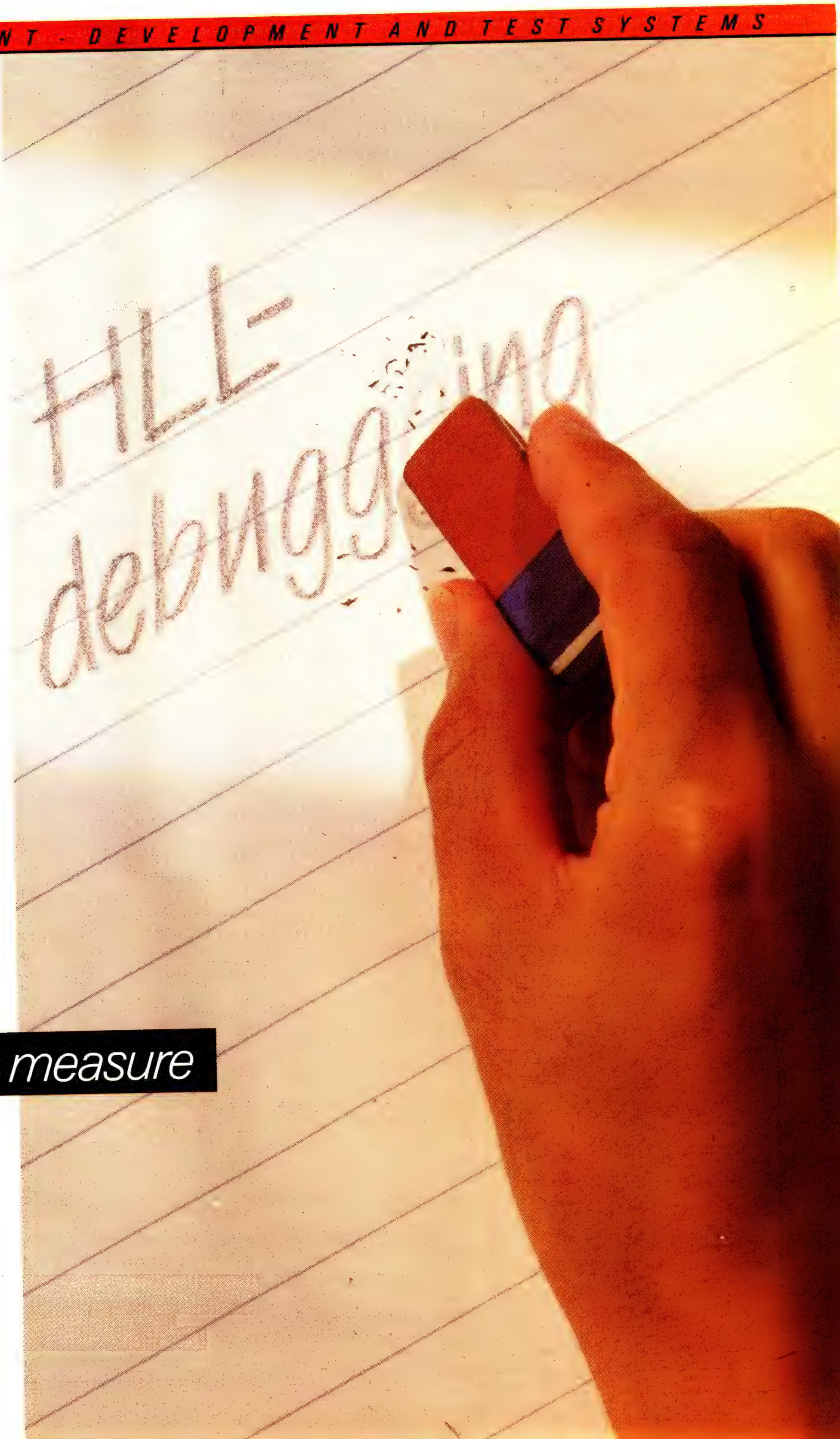

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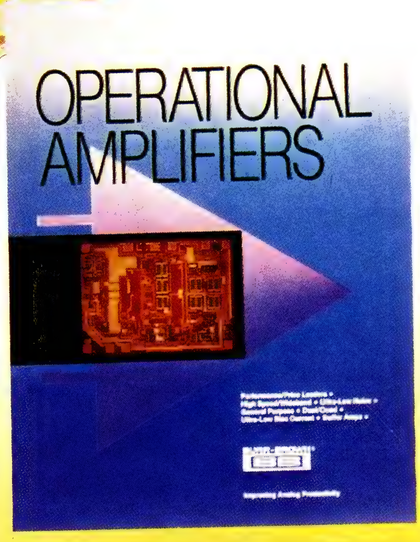
Advanced technology made to measure

LISTING 1 *(Continued)*

```
850 PRINT:PRINT "TRNSFMR. REGULATION COLD, ";RGNC
860 PRINT ", MUST BE INCREASED BY ADDITION OF SURGE RESISTOR"
870 PRINT:INPUT "ESTIMATE NEW COLD REGULATION (SUGGEST 10% INCREMENTS)" ;NRGNC
880 PRINT:RSRG = (VTRTDC/ITRTD)*(NRGNC-RGNC)/(NRGNC+1)
890 RGNC = NRGNC
900 RGNH = (RGNH*VTRTDH+ITRTD*RSRG)/(VTRTDH-ITRTD*RSRG)
910 VTRTDC = VTRTDC-ITRTD*RSRG
920 GOTO 530
930 VDMNR = 5.66*VHL/VNL*(RGNH+1)*VTRTDH/D
940 RSRGP=RSRG*(VNL/(VTRTDC2*(RGNC2+1)))^2
950 IF(D=2 AND S=1)THEN ITHA=.5*ITH ELSE ITHA=ITH
960 PTPRS = TPRS*(.5+.5*(IDC/IDCMAX)^2)
970 PRSRGP=RSRGP*((1+RGNC2)*VTRTDC1/VNL*ITHA)^2
980 PRINT: PRINT "OUTPUT FOLLOWS":PRINT
990 PRINT "SET UP PRINTER. "
1000 INPUT "IS PRINTER READY (PRESS RETURN IF YES)"; ZZZ
1010 LPRINT "VNL=";VNL,"VHL=";VHL,"VLL=";VLL,"FRQ=";FRQ,"IDC=";IDC,"VROM=";VROM,
"VROMN=";VROMN,"VR=";VR,"DBMNR=";DBMNR,"RIPO=";RIPO
1020 LPRINT "DIODES=";D,"SCNDRS.=";S,"VTRTDC1=";VTRTDC1,"ITRTD1=";ITRTD1,"TPRS="
;TPRS,"RGNC2=";RGNC2,"REGLTR= ";RG$,"RECTFRS= ";DX$,"XFMR= ";T$:LPRINT
1030 ITHA=ITHA*100:ITHA=CINT(ITHA):ITHA=ITHA/100
1040 LPRINT "TRANSFORMER CURRENT AT REQUIRED FULL LOAD, AC AMPS ="; ITHA
1050 IDCMAX=IDCMAX*100:IDCMAX=CINT(IDCMAX):IDCMAX=IDCMAX/100
1060 LPRINT "MAXIMUM ALLOWABLE CURRENT OUTPUT (WHEN LOAD INCREASED SO THAT"
1070 LPRINT "TRANSFORMER LOAD = LOAD AT FULL TEMP. RISE), DC AMPS = "; IDCMAX
1080 CMIN=CMIN*10000:CMIN=CINT(CMIN):CMIN=CMIN*100
1090 LPRINT "MINIMUM CAPACITY OF FILTER CAPACITOR, MICROFARADS = "; CMIN
1100 ICRMS=ICRMS*100:ICRMS=CINT(ICRMS):ICRMS=ICRMS/100
1110 LPRINT "RMS CAPACITOR CURRENT, AMPS = "; ICRMS
1120 VNLMX=VNLMX*10:VNLMX=CINT(VNLMX):VNLMX=VNLMX/10
1130 LPRINT "MAX. NO LOAD FILTER OUTPUT VOLTAGE, VOLTS = "; VNLMX
1140 VFLMX=VFLMX*10:VFLMX=CINT(VFLMX):VFLMX=VFLMX/10
1150 LPRINT "MAX. FULL LOAD FILTER OUTPUT VOLTAGE, VOLTS = " ; VFLMX
1160 VFLMN=VFLMN*10:VFLMN=CINT(VFLMN):VFLMN=VFLMN/10
1170 LPRINT "MIN. FULL LOAD FILTER OUTPUT VOLTAGE, VOLTS = "; VFLMN
1180 IF VFLMN<(VROM+VR)THEN 1190 ELSE 1220
1190 LPRINT "VFLMN < (VROM+VR). THIS REQUIRES EITHER LESS ALLOWABLE"
1200 LPRINT "OUTPUT RIPPLE OR HIGHER TRANSFORMER VOLTAGE, OR BOTH."
1210 GOTO 180
1220 PRGMX=PRGMX*10:PRGMX=CINT(PRGMX):PRGMX=PRGMX/10
1230 LPRINT "MAX. REGULATOR POWER DISSIPATION, WATTS ="; PRGMX
1240 PD=100*PD:PD=CINT(PD):PD=PD/100
1250 LPRINT "INDIVIDUAL RECTIFIER POWER DISSIPATION, WATTS ="; PD
1260 VDMNR=CINT(VDMNR)
1270 LPRINT "MINIMUM RECTIFIER REVERSE VOLTAGE, VOLTS ="; VDMNR
1280 IINRSH=CINT(IINRSH)
1290 LPRINT "MAX. INRUSH CURRENT, AMPS ="; IINRSH
1300 IDPR=IDPR*10:IDPR=CINT(IDPR):IDPR=IDPR/10
1310 LPRINT "REPETITIVE PEAK RECTIFIER CURRENT, AMPS ="; IDPR
1320 RSRGP=RSRGP*10:RSRGP=CINT(RSRGP):RSRGP=RSRGP/10
1330 LPRINT "SURGE RESISTOR (IF IN XFRMR PRIMARY), OHMS ="; RSRGP
1340 PRSRGP=100*PRSRGP:PRSRGP=CINT(PRSRGP):PRSRGP=PRSRGP/100
1350 LPRINT "POWER DISSIPATED IN SURGE RESISTOR, WATTS ="; PRSRGP
1360 PTPRS = CINT(PTPRS)
1370 LPRINT "PREDICTED TRANSFORMER TEMPERATURE RISE, DEG C ="; PTPRS
1380 INPUT "DO YOU WANT TO TRY ANOTHER TRANSFORMER (YES OR NO)"; B$
1390 IF (B$<>"YES") AND (B$<>"NO") THEN 1380
1400 IF (B$="YES") THEN 180 ELSE 1410
1410 PRINT "BE SURE TO CORRECTLY FUSE POWER SUPPLY AND CONFORM TO APPLICABLE"
1420 PRINT "SAFETY SPECIFICATIONS (EG. UL1012).":END
1430 PRINT:INPUT "TYPE RECTIFIER USED";DX$:PRINT "FIND TWO POINTS ON VERTICAL PA
RT OF RECTIFIER MAXIMUM I VS V CURVE WITH RATIO OF I1 TO I2, 1:10"
1440 PRINT:INPUT "I1 (AMPS)=";I1X:INPUT "V1 (VOLTS)=";V1X:INPUT "I2 (AMPS)=";I2X
:INPUT "V2 (VOLTS)=";V2X
1450 PRINT:PRINT "FIND TWO POINTS ON VERTICAL PART OF RECTIFIER MINIMUM I VS V C
URVE WITH RATIO OF I1 TO I2, 1:10"
1460  PRINT:INPUT "I1 (AMPS)=";I1N:INPUT "V1 (VOLTS)=";V1N:INPUT "I2 (AMPS)=";I2
N:INPUT "V2 (VOLTS)=";V2N
1470 RECT1=1/(1/(V2X-V1X)*LOG(I2X/I1X))
1480 RECT2=1/(I1X*(2.718^-(V1X/(V2X-V1X)*LOG(I2X/I1X))))
1490 RECT3=1/(1/(V2N-V1N)*LOG(I2N/I1N))
1500 RECT4=1/(I1N*(2.718^-(V1N/(V2N-V1N)*LOG(I2N/I1N))))
1510 GOTO 310
```

OP AMP SOLUTIONS



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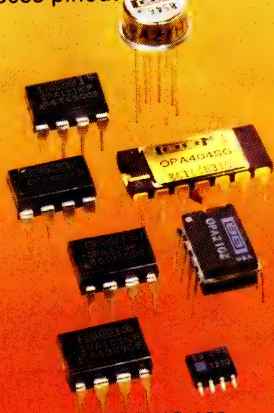

CIRCLE NO 153

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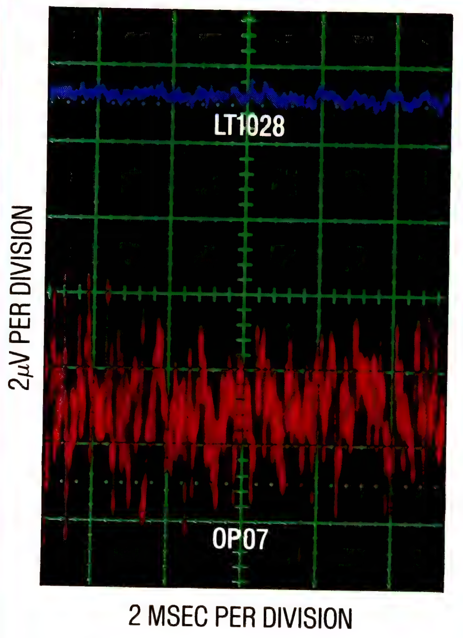
If you're ready to enter *The Quiet Zone,* ask about our LT1028 (or our LT1037 and LT1007 op amps). Pricing for the LT1028 family starts at $4.95 for the LT1028CN8 (in quantities of 100). This device is available in commercial and military temperature ranges and meets MIL-STD-883 specifications. For details, contact: LINEAR TECHNOLOGY CORPORATION, 1630 McCarthy Blvd., Milpitas, CA 95035. **800-637-5545.**



The LT1028 is 12-times less noisy than the OP07, the standard for low-noise op amps.

LINEAR TECHNOLOGY

TOUGH PRODUCTS
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CIRCLE NO 154

EDITED BY TARLTON FLEMING

Direction detector doubles as decoder

Tracy Allen
EME Systems, Berkeley, CA

Fig 1's circuit, which was developed to monitor the traffic of bumblebees in and out of the hive, differentiates "a-to-b" motion from "b-to-a" motion. When used with an optical decoder, the circuit distinguishes clockwise from counterclockwise rotation and provides a resolution of one output pulse per quadrature cycle. Although an earlier Design Idea achieves a resolution of four output pulses per quadrature cycle ("Improved tachometer eliminates backlash," *EDN*, March 31, 1987, pg 210), **Fig 1**'s circuit is simpler and less expensive.

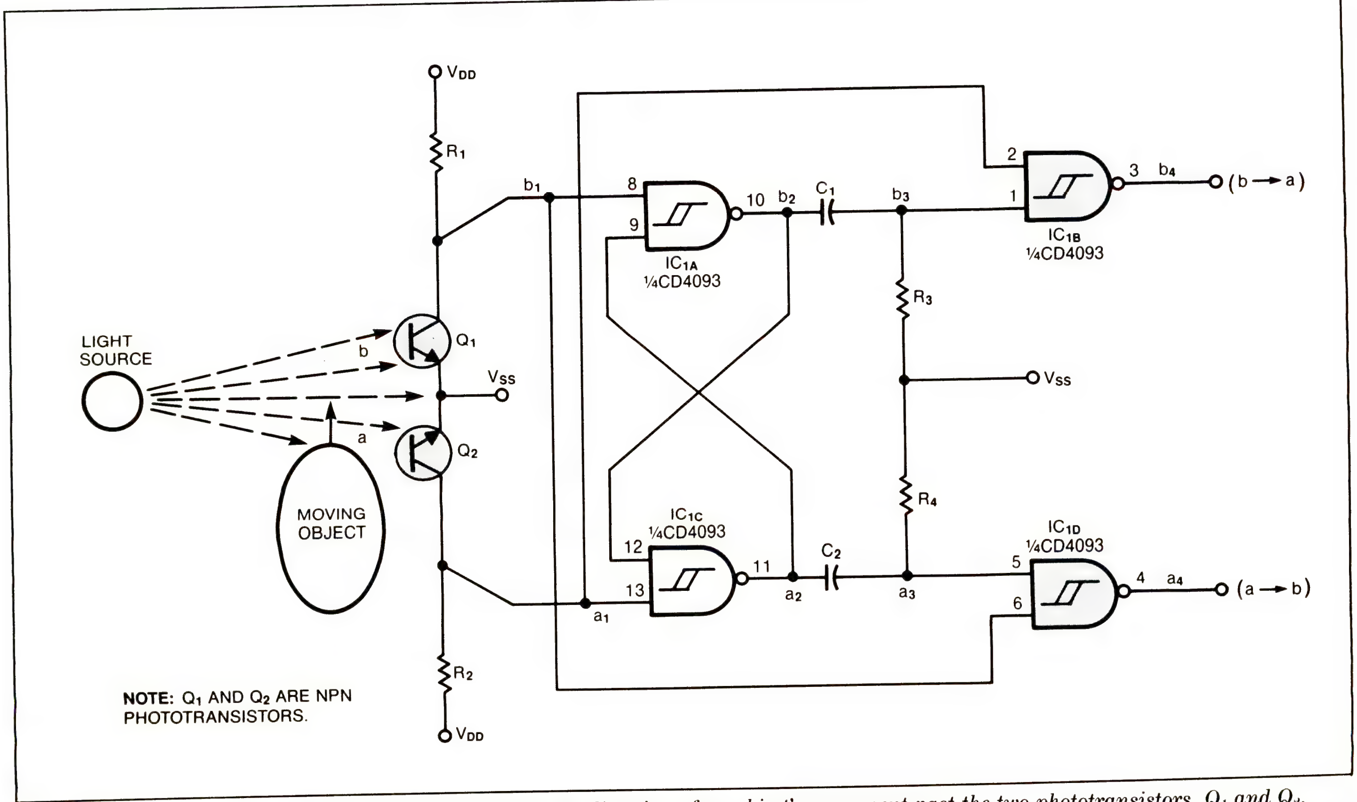
Q_1 and Q_2 are mounted so that a moving object first blocks one phototransistor, then both, then the other. Depending on the direction in which the object is moving, either IC_{1B} or IC_{1D} emits a negative pulse when the moving object blocks the second sensor. An object can get as far as condition 3 (see **Table 1**) and retreat without producing an output pulse; that is, the circuit ignores any probing or jittery motion. (If an object gets as far as condition 4, however, a retreat will produce an opposite-direction pulse.)

TABLE 1—LOGIC STATES FOR a-TO-b MOTION (INTERCHANGE a AND b FOR b-TO-a MOTION)

CONDITION	INPUTS		INTERMEDIATE VARIABLES				OUTPUTS	
	a_1	b_1	a_2	b_2	a_3	b_3	a_4	b_4
1) NO PASSAGE	0	0	1	1	0	0	1	1
2) OBJECT BLOCKS a	1	0	0	1	0	0	1	1
3) OBJECT BLOCKS a AND b	1	1	0	1	0	0	1	1
4) OBJECT BLOCKS b	0	1	1	0	_⎍_	0	‾⊔‾	1
5) NO PASSAGE	0	0	1	1	0	_⎍_	1	1

The time constants R_3C_1 and R_4C_2 set the output-pulse width. A 100-kΩ/100-pF combination, for example, produces 10-μsec pulses. You select a value for pullup resistors R_1 and R_2 from the 10k- to 100k-Ω range, according to the sensitivity your application requires. **EDN**

To Vote For This Design, Circle No 746



NOTE: Q_1 AND Q_2 ARE NPN PHOTOTRANSISTORS.

***Fig 1—Each output pulse from this circuit** represents the direction of an object's movement past the two phototransistors, Q_1 and Q_2.*

Circuit selects single or multiple lines

Bob Mostafapour
General Motors Corp, Lansing, MI

With switch S_1 in the normal position, the pushbutton-actuated circuit of **Fig 1** latches a Q output high each time you depress the corresponding pushbutton. That Q output returns low when you depress another pushbutton (unless you continue pressing the first).

Depressing a pushbutton applies 5V to one of IC_2's data inputs. At the same time, the corresponding 470-pF capacitor and the resistor R_1 debounce the contact closure; these two components also differentiate the 5V step, which applies a positive pulse to the Latch-Enable input (pin 1). The pulse's falling edge latches the data inputs (one high and the rest low, provided S_1 is in the normal position).

When S_1 is in the concurrent position, however, the circuit doesn't clear the previously selected line, and you can latch as many lines as you want—provided you depress all the corresponding pushbuttons within 10 seconds or so. If you let the output lines drive analog switches, for instance, this mode of operation can help you mix analog signals together or provide pushbutton control of an amplifier's gain.

Switching S_1 to the concurrent position places IC_1's outputs in the high-impedance state. Consequently, for each button you press, one of the 1-µF capacitors will charge to 5V, thereby retaining a memory of that selection.

EDN

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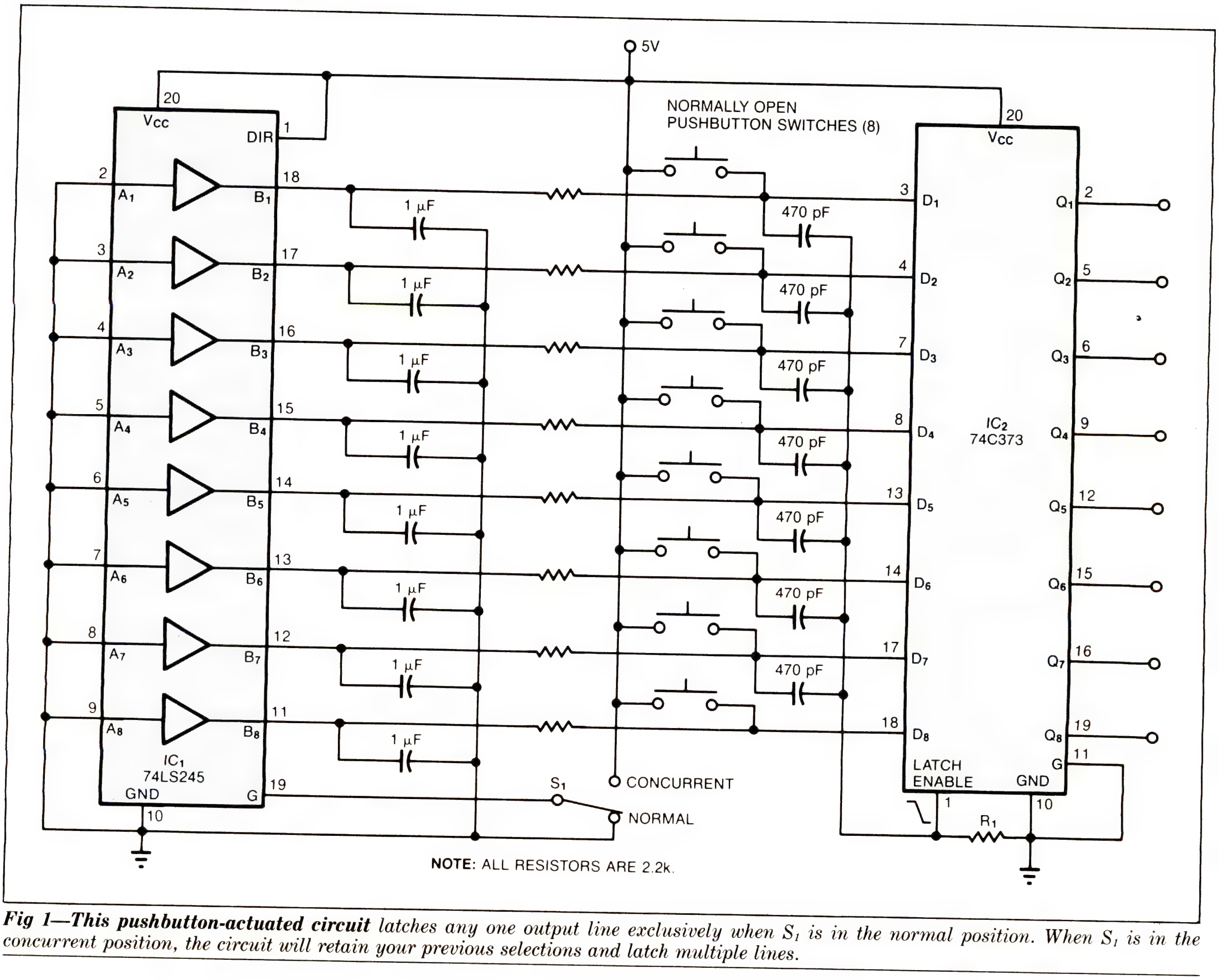

NOTE: ALL RESISTORS ARE 2.2k.

*Fig 1—**This pushbutton-actuated circuit** latches any one output line exclusively when S_1 is in the normal position. When S_1 is in the concurrent position, the circuit will retain your previous selections and latch multiple lines.*

tiny SPDT switch

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SPECIFICATIONS

FREQ. RANGE	dc-4.6 GHz	
INSERT. LOSS (db)	typ	max
dc-200MHz	0.9	1.1
200-1000MHz	1.0	1.3
1-4.6GHz	1.3	1.7
ISOLATION (dB)	typ	min
dc-200MHz	60	50
200-1000MHz	45	40
1-4.6GHz	30	23
VSWR (typ)	1.3:1	
SW. SPEED (nsec)		
rise or fall time	2(typ)	
MAX RF INPUT (dBm)		
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above 500MHz	+27	
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CIRCLE NO 155

Standard logic provides interrupts for Z80

Don Johnson
Network Sciences Corp, Newport Beach, CA

The circuit of **Fig 1a** implements vectored interrupts in a Z80-based system without requiring Z80-peripheral devices—a counter/timer circuit (CTC), for example, or a serial I/O (SIO) chip. First, configure the Z80 for mode 2 interrupt operation. In this mode, the µP responds to a low level on its $\overline{INT}$ input by using the contents of its 8-bit I register to access a memory-based table of interrupt-handler addresses. (You must store this table on a modulo-256 address boundary.) During the interval when $\overline{M1}$ and $\overline{IORQ}$ are low **(Fig 1b)**, the interrupting device supplies an 8-bit vector that enables the µP to select an address from the table.

As shown, **Fig 1a** supports eight interrupts. You can

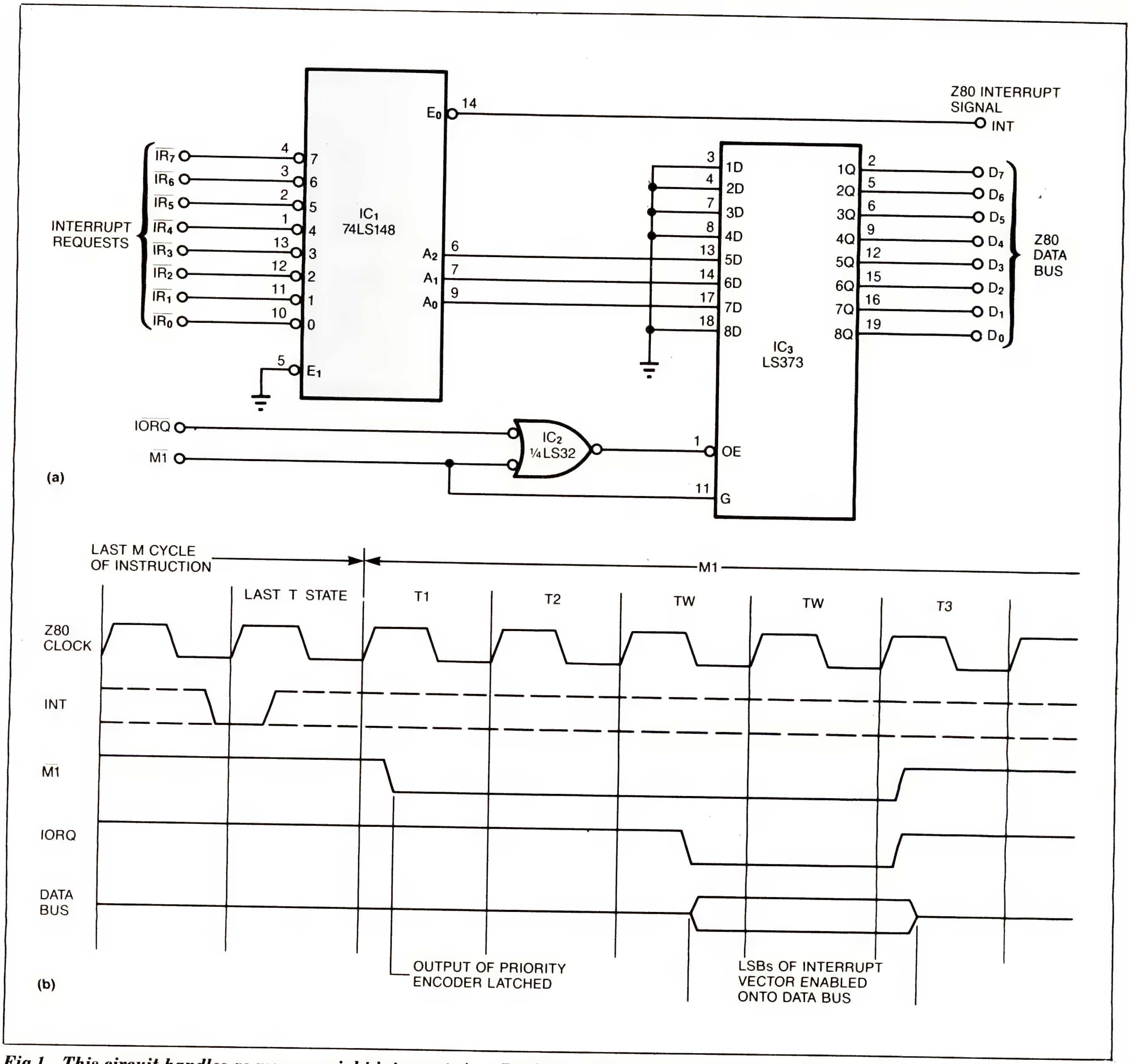

Fig 1—This circuit handles as many as eight interrupts *in a Z80-based system without using specialized peripheral devices* ***(a)****. The timing diagram* ***(b)*** *shows that the interrupting device must identify itself by supplying an 8-bit vector while* $\overline{M1}$ *and* $\overline{IORQ}$ *are low.*

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BUS SIZE	CPU FAMILY	SOFTWARE COMPATIBILITY	883	DESC	JAN	SYSTEM SOFTWARE
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16-BIT	Z8001		X	X	X	ADA
	Z8002		X	X	X	
	Z8005		X			
	Z8030 Z-SCC		X	X		
	Z8530 SCC		X	X		
	Z8036 Z-C10		X	X		
	Z8536 C10		X	X		
	Z8581 CGC		X	X		
	Z8038 FI0		X			
8-BIT	Z280	↕	△			C
	Z180		△			
	Z80		X	△	X	
	Z8420 PIO		X	X		
	Z8430 CTC		X	X		
	Z8440 SIO		X	△		
	Z8441 SIO		X	△		
	Z8442 SIO		X	X		
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CIRCLE NO 156

increase this number to 16 by adding an LS00 gate and another 74LS148; the second 74LS148 uses the first 74LS148's E_1 input (pin 5, connected to ground in **Fig 1a**) as a chip-enable input.

The interrupt signal from each interrupting device must go low and remain low until reset by the interrupt-handler subroutine. If the interrupting device generates a pulse instead of a level change, you must supply an edge-triggered flip-flop to capture and retain the interrupt signal. **Listing 1** contains assembly-code fragments for initializing the Z80's I register, for entering and exiting from the interrupt-handler subroutines, and for setting up the interrupt-handler address table. **EDN**

To Vote For This Design, Circle No 750

LISTING 1—CODE FRAGMENTS FOR INTERRUPT SYSTEM

```
                              .Z80
                              TITLE Z80 INTERRUPT MODE 2 DEMO
0000'                         ASEG

                              ORG   0                 ; start at address 0

0000                      STARTUP:

                          ;-----    I Register initialization

0000        3E 01                 LD    A,HIGH VECTORS    ; get msb bits of vector table address
0002        ED 47                 LD    I,A               ; load I register
0004        ED 5E                 IM    2                 ; enable interrupt mode 2
0006        FB                    EI                      ; enable interrupts

                          ; the rest of the non-interrupt handler code follows


                          ;----- typical interrupt handler entry and exit code

0007                      IHO:                            ; interrupt #0 handler entry
0007        08                    EX    AF,AF'            ; save registers (or push on stack)
0008        D9                    EXX

                          ; body of code goes here including the instructions to reset the interrupt

0009        D9                    EXX                     ; restore registers
000A        08                    EX    AF,AF'
000B        FB                    EI                      ; enable interrupts
000C        C9                    RET                     ; don't need RETI because interrupt
                                                          ; acknowledges are not needed

000D                      IH1:                              ; other interrupt handler entry points
000D                      IH2:
000D                      IH3:
000D                      IH4:
000D                      IH5:
000D                      IH6:
000D                      IH7:
000D        FB                    EI                      ; enable interrupts
000E        C9                    RET                     ; exit


                          ;----- interrupt handler address table

                                  ORG   ($/256+1)*256     ; make table address mod 256

0100                      VECTORS:
0100        0007                  DEFW  IH0               ; interrupt handler #0 address
0102        000D                  DEFW  IH1
0104        000D                  DEFW  IH2
0106        000D                  DEFW  IH3
0108        000D                  DEFW  IH4
010A        000D                  DEFW  IH5
010C        000D                  DEFW  IH6
010E        000D                  DEFW  IH7

                                  END
```

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CIRCLE NO 157

Voltage regulator has precise I_{OUT} limit

Rush Hood
Critikon Inc, Tampa, FL

A monolithic, adjustable, 3-terminal regulator provides excellent voltage regulation and overcurrent protection, but some applications require a better-controlled or lower-valued current limit than the chip alone can provide. In the regulator circuit of **Fig 1,** IC_1 provides a basis for current limiting and dissipates most of the power while the shunt regulator (IC_2) provides precise voltage regulation. You independently program the current limit and V_{OUT} using external resistors.

During operation, IC_1 keeps its output voltage 1.25V higher than the voltage at the ADJ terminal. R_4 is in series with IC_1's feedback signal, which allows IC_2 to control V_{OUT} by drawing current through the resistor. IC_2 regulates V_{OUT} by maintaining 2.5V at its Ref terminal; accordingly, you choose R_1 and R_2 to provide the desired V_{OUT}: $V_{OUT}=2.5(1+R_2/R_1)$.

In addition, you select the value of resistor R_3 so that it drops 1.25V when the output is delivering the desired limit current. During normal operation, an increasing load current causes the voltage across R_3 to increase as R_4's voltage decreases. (At the desired current-limit value, the voltage across R_4 goes to zero.) The current limit established for **Fig 1** (123 mA) varies less than 1 mA over the V_{IN} range of 10 to 30V. The line regulation measures 0.001%/V over the same range, and the load regulation measures 0.1% over the I_{OUT} range of 0 to 110 mA.

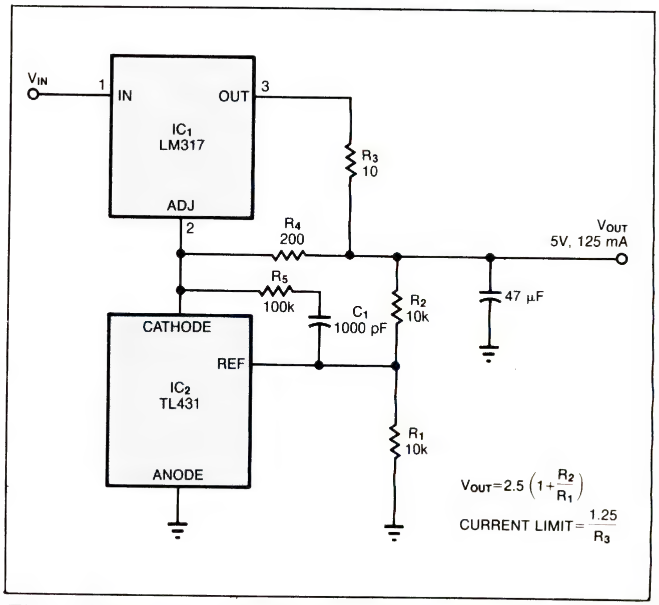

Fig 1—Thanks to its separate monolithic, adjustable, regulator ICs, *you can program this circuit's output voltage and current limit independently.*

Components R_5 and C_1 stabilize the circuit by providing frequency compensation. The minimum V_{IN} equals 1.25V plus IC_1's minimum overhead requirement; the minimum V_{OUT} equals the sum of the IC's reference voltages, 1.25+2.50=3.75V. **EDN**

To Vote For This Design, Circle No 749

Current source uses instrumentation amp

James Wong and Derek Bowers
Precision Monolithics Inc, Santa Clara, CA

A precision current source such as a Howland current pump requires well-matched resistors for proper operation; any mismatch will reduce the source's output impedance (which is ideally infinite). By including a monolithic instrumentation amplifier that incorporates the matched resistors, you can build a current source that is easy to use and calibrate.

Fig 1 shows a simple bilateral current source based on the unconventional application of an instrumentation amplifier, in which you apply V_{IN} between the Ref and Sense terminals. IC_1's gain equals $20(R_{SENSE}/R_{GAIN})$. If you set the gain to 1, then $I_{OUT}=V_{IN}/R_1$. (R_{SENSE} and R_{GAIN} affect only the gain accuracy, not the amplifier's

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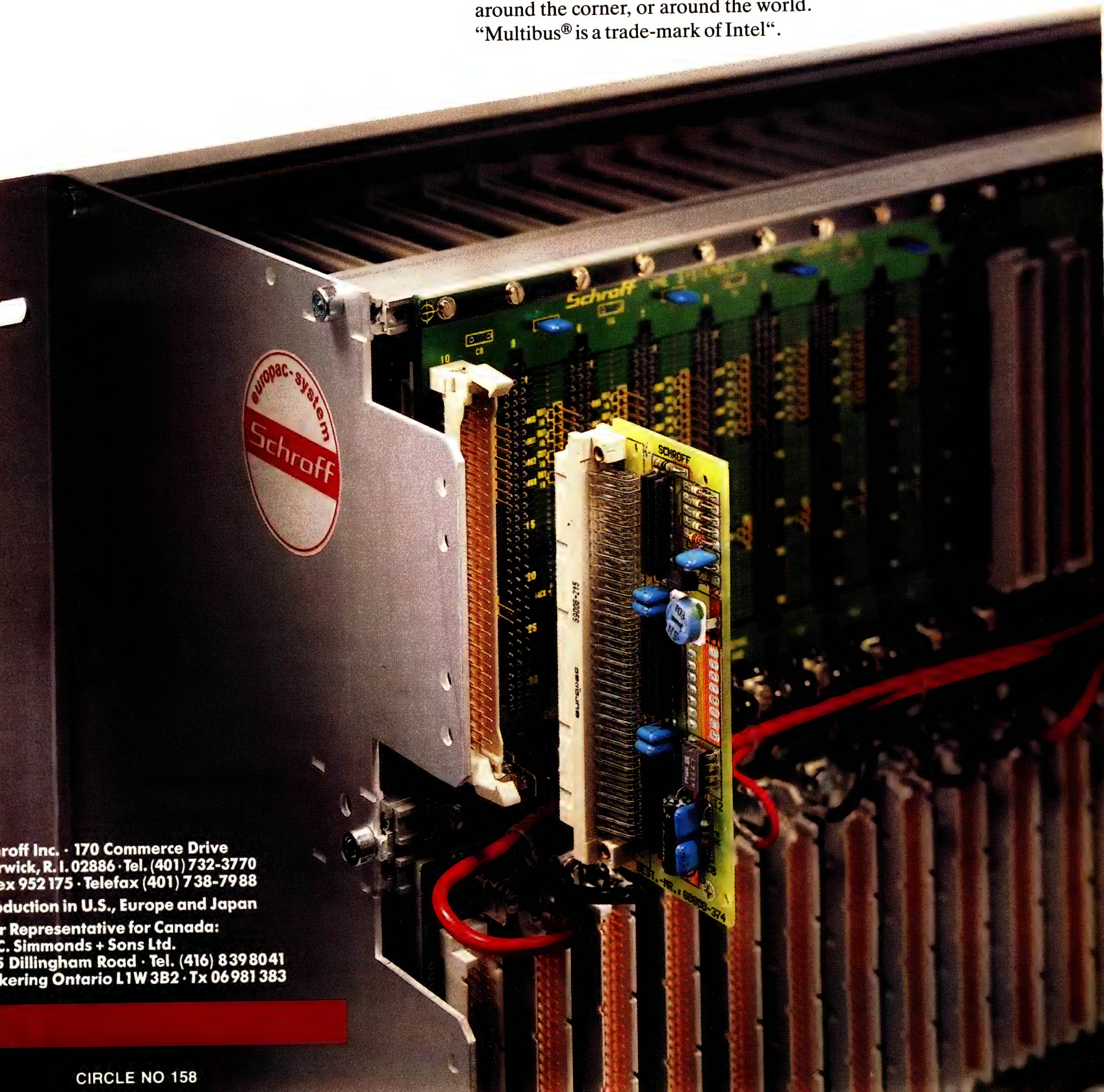

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CIRCLE NO 158

common-mode rejection or linearity.)

For the component values shown and when $V_{IN}=1V$, the circuit produces a flow of 10 mA into the I_{OUT} terminal. The load may connect to ground or to another voltage, provided that I_{OUT} remains within its compliance-voltage range of ±10V. Although the IC can produce more than 20 mA of output current, you should limit I_{OUT} to less than 10 mA to avoid linearity errors caused by self-heating. The loaded current source can achieve better than 15-bit linearity if you follow this rule.

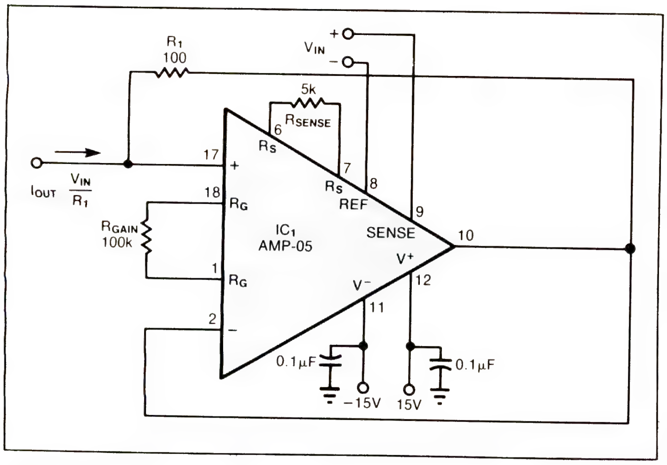

***Fig 1—This simple current source** delivers a maximum of about ±10 mA and exhibits negligible crossover distortion below 20 Hz.*

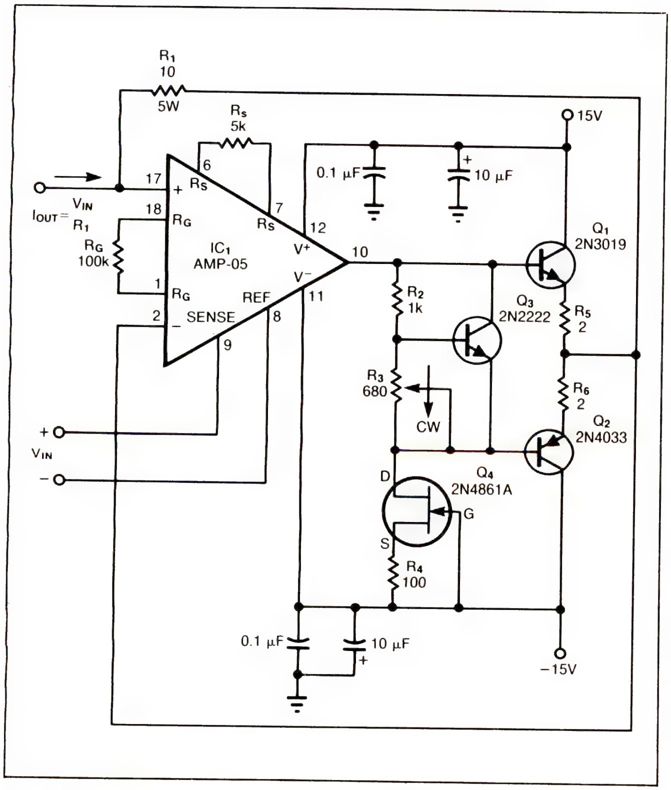

***Fig 2—Adding two output transistors to Fig 1's circuit** boosts I_{OUT} to ±0.5A. The other transistors minimize crossover distortion by ensuring that the output transistors remain in conduction.*

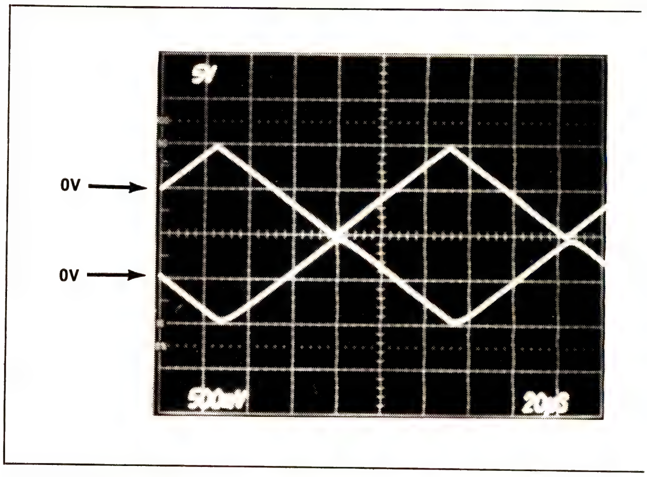

***Fig 3—The bottom trace of this scope photo** shows the outpu waveform for the current source of **Fig 2** with a 10Ω load attached (The top trace is V_{IN}, ±5V.)*

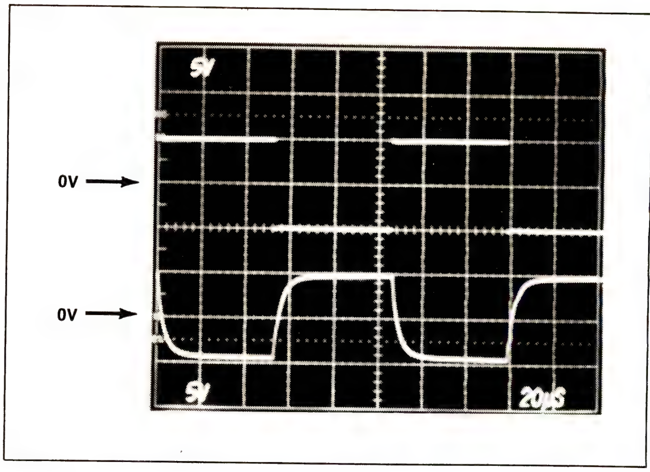

***Fig 4—This pulse-response waveform (bottom trace)** shows that **Fig 2's** output (I_{OUT}) swings between +0.5A and −0.5A in about 20 µsec.*

Adding discrete transistors allows the circuit to achieve higher levels of I_{OUT}. In **Fig 2**, for example, Q_1 and Q_2 enable the circuit to sink and source 0.5A. Q_3 and Q_4 (and associated components) minimize crossover distortion by ensuring that Q_1 and Q_2 remain in conduction (and therefore offer low source impedance) in the vicinity of zero crossover.

Q_4 provides about 10 mA of bias current to Q_3. The combination of R_2, R_3, and Q_3 creates a voltage of approximately $2V_{BE}$ between the bases of Q_1 and Q_2. You should set R_3 fully clockwise, then adjust it in the counterclockwise direction until the output stage's quiescent current equals 10 mA. The result is an output waveform without measurable crossover distortion (**Fig 3**). What's more, it takes less than 20 µsec for the output current to swing between +0.5A to −0.5A (**Fig 4**). **EDN**

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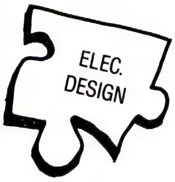

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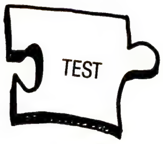

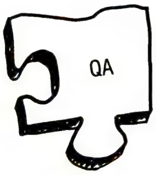

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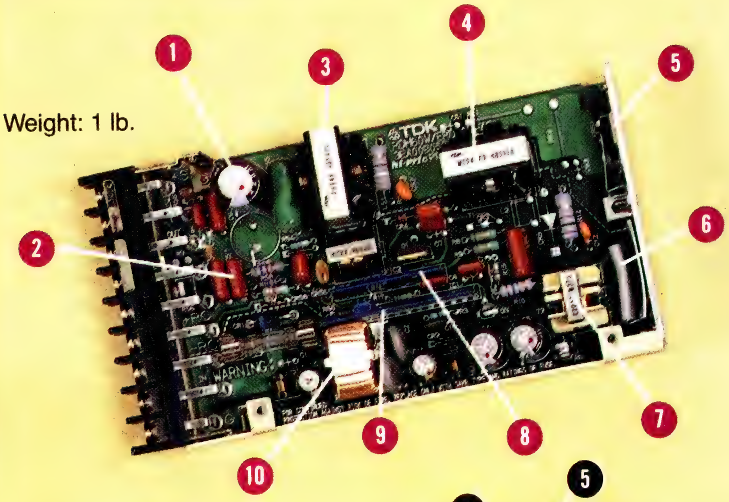

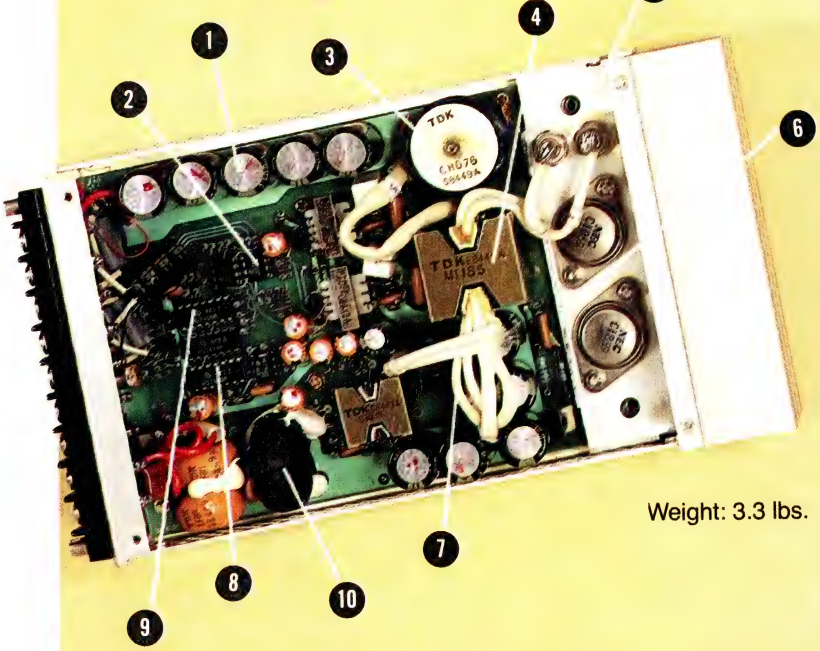

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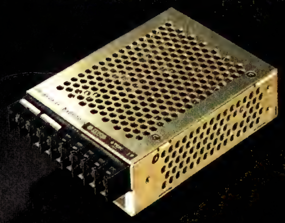

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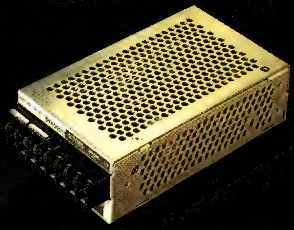

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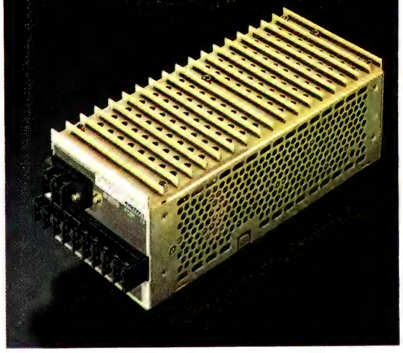

STABILIZATION

Specification	Condition	Typical	Maximum
Source effect	min-max	0.2%	0.8%
Load effect	10%-100%	0.3%	1%
Temperature effect	0°C~71°C	0.3%	1%
Combined effect*	envelope	0.6%	2%
Time effect	8-hr drift @ 25°C	0.1%	0.5%

*Source, load, & temperature

ENVIRONMENT

(Tested to MIL-STD-810D environmental test methods for ground equipment)

Ambient operating temperature range: 0°C to +71°C

Storage temperature range: −20°C to + 75°C

Humidity: 20-95% RH, noncondensing

Vibration:
5-10 Hz: 10mm, 3 axes
10-55 Hz: 2g, 3 axes

Shock: 20g, 3 axes (11 ± 5ms pulse duration)

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between output terminals and chassis:
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Conducted EMI:
MIL-STD-461, Method CEO3 Broadband

Safety: All models meet UL 478 and CSA C22.2-154.

SPECIFICATIONS

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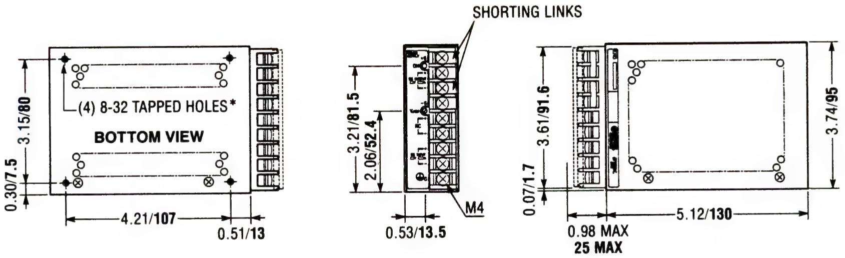
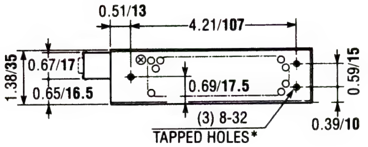
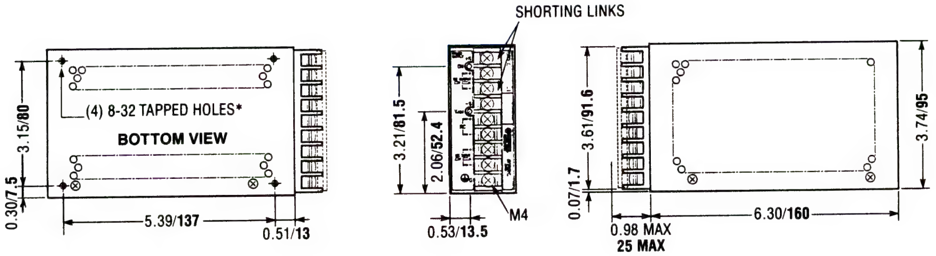
* Maximum allowable mounting screw penetration is 0.3/7

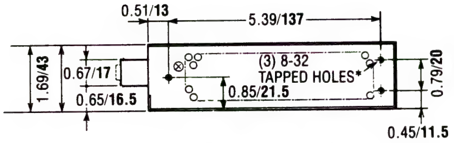


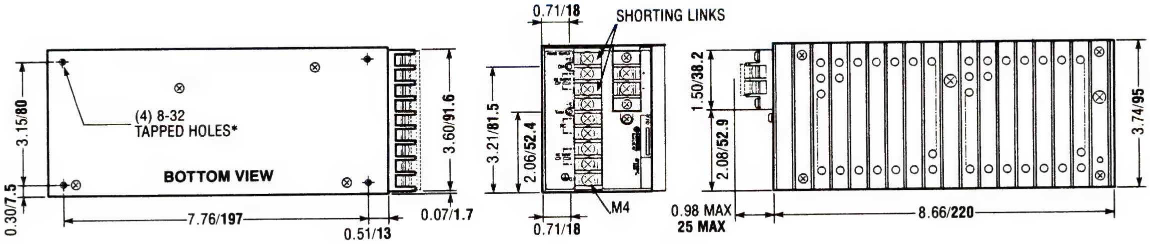
30 WATT MODELS



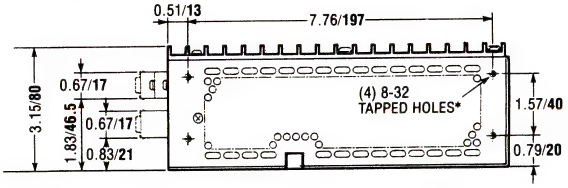


60 WATT MODELS



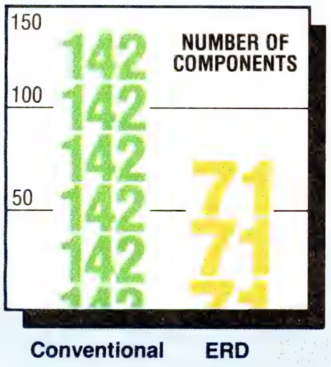


150 WATT MODELS

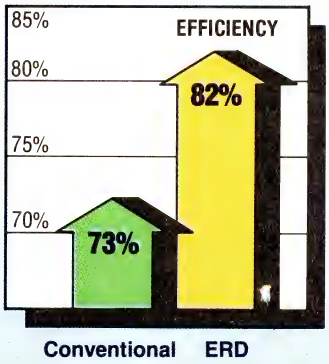


Compared to conventional d-c to d-c converters operating at 25 KHz, our new 300 KHz Series ERD gives you:

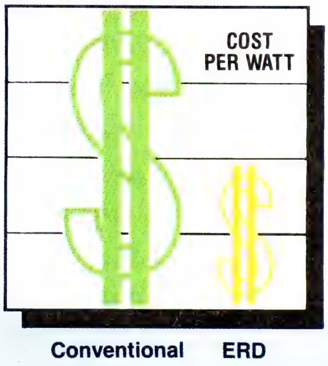
50% CUT IN PARTS POPULATION



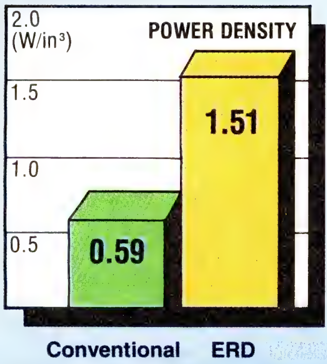
UP TO 10% GREATER EFFICIENCY



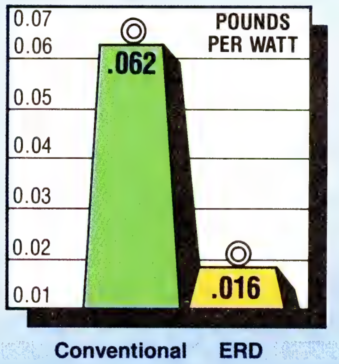
50% CUT IN COST PER WATT



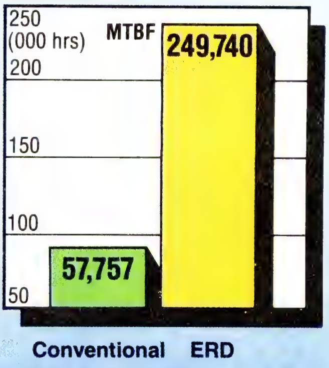
ALMOST TRIPLE POWER DENSITY



A 70% REDUCTION IN WEIGHT



NEARLY 5X BETTER MTBF *



*Ground benign, 25°C.

This KEPCO product is backed by a firm **5-YEAR WARRANTY**

KEPCO
THE POWER SUPPLIER™

Model Number		ERD 5-6-24 5-6-48	ERD 12-2.5-24 12-2.5-48	ERD 15-2-24 15-2-48	ERD 24-1.3-24 24-1.3-48	ERD 48-0.6-24 48-0.6-48
Output Volts		5	12	15	24	48
Adjustment Range		4.0~5.5	8.4~13.2	12~16.5	16.8~26.4	32.6~52.8
Output Current, Amperes	50°C	6	2.5	2	1.3	0.6
	60°C	4.2	1.8	1.4	0.9	0.4
	71°C	2.4	1.0	0.8	0.5	0.2
Current Limit (Amps)		6.6~7.1	2.8~3.1	2.3~2.6	1.5~1.8	0.7~1.0
OVP Setting (Volts)		6.0~6.9	13.7~15.7	17.0~19.5	27.0~30.5	55.0~63.0
Ripple (mV, p-p)	(typ)	30	50	50	50	60
	(max)	50	80	80	100	150
Spike noise (mV, p-p max.)		100	170	200	290	530

Input current (at 25°C):
At nominal input voltage, 50°C power rating
24V models: 1.6A typ., 1.8A max.
48V models: 0.8A typ., 0.9A max.
At minimum input voltage, 50°C power rating
24V models: 2.2A max./48V models: 1.1A max.
At nominal input voltage, no load
24V models: 150 mA max.
48V models: 100 mA max.
Source voltage range:
24V models: 20-30V d-c
48V models: 40-56V d-c
Input fuse value:
24V models: 4 Amps/48V models: 2.5 Amps.

Efficiency (typ): 77%
Switching frequency: 300 KHz.
Configuration: Forward Converter

KEPCO®
THE POWER SUPPLIER™

These ratings are for "vertical" installation. For use horizontally, derate by 20%.
MOVING AIR (5 CFM) IS SUFFICIENT TO AVOID DERATING IN HORIZONTAL POSITION.

Model Number		ERD 5-12-24 5-12-48	ERD 12-5-24 12-5-48	ERD 15-4-24 15-4-48	ERD 24-2.5-24 24-2.5-48	ERD 48-1.2-24 48-1.2-48
Output Volts		5	12	15	24	48
Adjustment Range		4.0~5.5	8.4~13.2	12~16.5	16.8~26.4	32.6~52.8
Output Current, Amperes	50°C	12	5	4	2.5	1.2
	60°C	8.4	3.5	2.8	1.8	0.8
	71°C	4.8	2.0	1.6	1.0	0.5
Current Limit (Amps)		13.2~13.8	5.6~6.0	4.5~4.9	2.8~3.1	1.4~1.7
OVP Setting (Volts)		6.0~6.9	13.7~15.7	17.0~19.5	27.0~30.5	55.0~63.0
Ripple (mV, p-p)	(typ)	30	50	50	50	60
	(max)	50	80	80	100	150
Spike noise (mV, p-p max.)		100	170	200	290	530

Input current (at 25°C):
At nominal input voltage, 50°C power rating
24V models: 3.3A typ., 3.5A max.
48V models: 1.6A typ., 1.7A max.
At minimum input voltage, 50°C power rating
24V models: 4.3A max./48V models: 2.1A max.
At nominal input voltage, no load
24V models: 150 mA max.
48V models: 100 mA max.
Source voltage range:
24V models: 20-30V d-c
48V models: 40-56V d-c
Input fuse value:
24V models: 6.3 Amps/48V models: 4 Amps.

Efficiency (typ): 24V models: 79%/48V models: 82%
Switching frequency: 300 KHz.
Configuration: Forward Converter

These ratings are for "vertical" installation. For use horizontally, derate by 20%.
MOVING AIR (5 CFM) IS SUFFICIENT TO AVOID DERATING IN HORIZONTAL POSITION.

Model Number		ERD 5-30-24 5-30-48	ERD 12-12-24 12-12-48	ERD 15-10-24 15-10-48	ERD 24-6-24 24-6-48	ERD 48-2.8-24 48-2.8-48
Output Volts		5	12	15	24	48
Adjustment Range		4.0~5.5	8.4~13.2	12~16.5	16.8~26.4	32.6~52.8
Output Current, Amperes	50°C	30	12	10	6	2.8
	60°C	21	8.4	7	4.2	2.0
	71°C	12	4.8	4	2.4	1.1
Current Limit (Amps)		33~35	13.4~14.4	11.2~12.0	6.8~7.3	3.3~3.6
OVP Setting (Volts)		6.0~6.9	13.7~15.7	17.0~19.5	27.0~30.5	55.0~63.0
Ripple (mV, p-p)	(typ)	30	50	50	50	60
	(max)	50	80	80	100	150
Spike noise (mV, p-p max.)		100	170	200	290	530

Input current (at 25°C):
At nominal input voltage, 50°C power rating
24V models: 8.0A typ., 8.5A max.
48V models: 3.8A typ., 4.1A max.
At minimum input voltage, 50°C power rating
24V models: 10.5A max.
48V models: 5.0A max.
At nominal input voltage, no load
24V models: 150 mA max.
48V models: 100 mA max.
Source voltage range:
24V models: 20-30V d-c
48V models: 40-56V d-c
Input fuse value:
24V models: 15 Amps/48V models: 8 Amps.

Efficiency (typ): 24V models: 79%/48V models: 81%
Switching frequency: 24V models: 220 KHz/48V models, 300 KHz
Configuration: Forward Converter

These ratings are for "vertical" installation. For use horizontally, derate by 20%.
MOVING AIR (5 CFM) IS SUFFICIENT TO AVOID DERATING IN HORIZONTAL POSITION.

KEPCO/TDK HEAVY DUTY, INDUSTRIAL GRADE SINGLE OUTPUT d-c TO d-c CONVERTERS

The 300KHz switching frequency of our new Series ERD is not the *only* reason we can make it so much smaller and lighter than conventional, 25KHz d-c to d-c converters. Advanced switching techniques and hybrid microcircuitry employing the latest surface mount technology also contribute. But 300KHz switching is still the major factor; and the basic reason we can produce such high frequency switchers is the development — by TDK — of H7C4, a new low-loss ferrite that can handle such high frequencies.

SERIES ERD OFFERS THESE FEATURES ESSENTIAL FOR DEMANDING INDUSTRIAL APPLICATION:

- **Adjustable voltage output:** −30% to +10% of nominal.*
- **Transformer isolated output:** allows independent grounding of input and output.
- **Remote error sensing,** which allows the ERD to ignore the effect of load wire voltage drop up to 0.4V per wire.
- **Remote on-off:** A TTL-compatible logic level signal can be used to turn the power supply on and off at the ±RC terminals. It is optically isolated so that it need not be common to the power supply.
- **Overvoltage protection,** which shuts off the switching oscillator and reduces the output to zero, when output voltage tries to exceed the preset limit.
- **Rectangular current limiting,** to drive non-linear loads and allows for paralleling.
- **Power OK indicator, green LED.**
- **A built-in EMI filter capable of meeting conducted noise standard MIL-STD-461B.**
- **Certified to meet MIL STD 810D environment:**

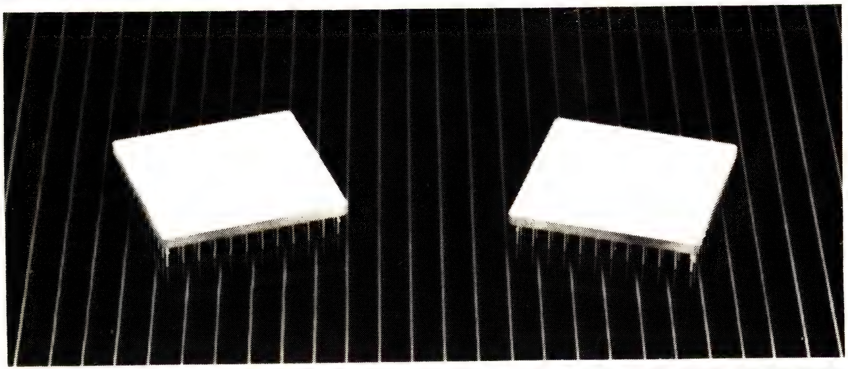
500.1 Procedure I Low pressure	**503.1** Procedure I Temperature shock	**508.1** Procedure I Fungus
501.1 Procedure I, II High temperature	**504.1** Procedure I Temperature – altitude	**514.2** Procedure I, X Vibration
502.1 Procedure I Low temperature	**507.1** Procedure I Humidity	**516.2** Procedure I, III Shock

**Except 5V and 15V model. −20% to +10%.*

KEPCO®
THE POWER SUPPLIER™

NEW PRODUCTS

INTEGRATED CIRCUITS



VIDEO DAC

- *125M-sample/sec update rate*
- *8-bit resolution*

The Bt457 is an 8-bit video D/A converter that's pin-compatible with the firm's existing Bt451 and Bt458 products. The monolithic CMOS Bt457 includes a 256-byte×8-bit color look-up table and operates with a clock frequency (input data rate) as high as 125 MHz. The chip is suitable for monochrome- or color-video applications; its multiplexer provides 4:1 or 5:1 data-rate reductions. The converter also features programmable blink rates, bit-plane masking and blinking, color-overlay capability, and a dual-port, color-palette RAM. It includes high-speed logic that minimizes the use of external ECL-interface circuitry and lets you create bit-mapped color-graphics displays with resolutions as high as 1280×1024 pixels. Multiplexed TTL pixel ports allow 32-MHz data transfers to the frame buffer while maintaining a 125-MHz update rate at the DAC's output. The outputs can drive a 75Ω coax directly. The package is an 84-pin ceramic pin-grid array. 125-MHz version, $140; 110-MHz version, $123; 80-MHz version, $105 (100).

Brooktree Corp, 9950 Barnes Canyon Rd, San Diego, CA 92121. Phone (619) 452-7580. TLX 383596.

Circle No 371

MOTOR DRIVER

- *Drives 3-phase brushless dc motors to 3A*
- *Limits output slew rate to minimize EMI*

The L6230 is a single-chip driver for 3-phase brushless dc motors. It can deliver an output current of 3A from supply voltages as high as 18V. The controller accepts differential inputs from three Hall-effect sensors and includes all the logic necessary to commutate the motor winding currents. You can use the driver with motors that have either star or delta-connected windings, and a direction input to the IC allows you to select forward or reverse motor rotation. The driver has a motor-speed-indication output (producing one pulse per motor revolution), which you can compare to a reference frequency in a PLL. The output of the PLL connects to the driver's speed-control input and controls the motor winding current. The motor driver is also compatible with F-to-V speed-control systems. To avoid generating EMI during commutation, the driver limits the slew rate of the output stages to 0.1V/μsec typ. The L6230 comes in a 15-lead Multiwatt package and costs around $5 (100). A unidirectional version, the L6231, is also available.

SGS Microelettronica SpA, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 372

SGS Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 373

VIDEO BUFFER

- *200-MHz bandwidth*
- *±5V operation*

The hybrid LH4002 is a unity-gain buffer amplifier that can drive 50Ω and 75Ω loads at frequencies greater than 200 MHz. The device is suitable for video distribution, impedance transformation, and increasing the output-current capability of conventional op amps. Intended for operation with ±5V supplies, the buffer provides a 1000V/μsec min slew rate, 2° phase linearity (from 1 to 20 MHz), and less than 0.1% distortion. The LH4002 is pin-compatible with the industry-standard LH0002, and it comes in a 10-pin plastic DIP or an 8-pin TO-5 metal can. The plastic DIP has better heat transfer than the metal can, providing a thermal impedance of 120°C/W (vs 125°C/W for the metal can). Mil-processed versions are available. From $9.50 (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-5856. TLX 346353.

Circle No 374

PRECISION OP AMP

- *600-pA max input bias current over MIL temp range*
- *120-μV max V_{OS}*

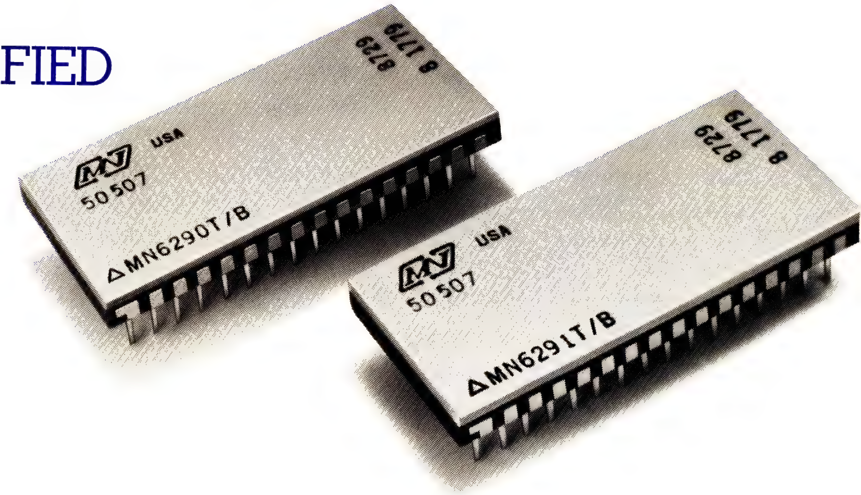
The PM-1008 precision op amp is pin and function compatible with the OP-08 and 108-type op amps, but offers better dc characteristics. Superbeta input transistors and a

Text continued on pg 268

FFT-TESTED 12-16 BIT SAMPLING A/D's

MIL-STD-1772 CERTIFIED

MN6000 Series

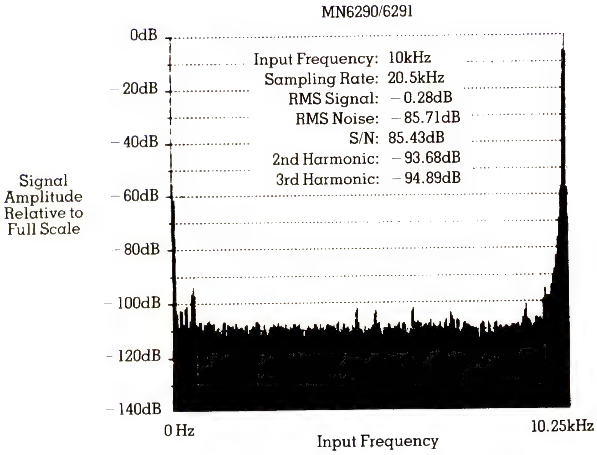


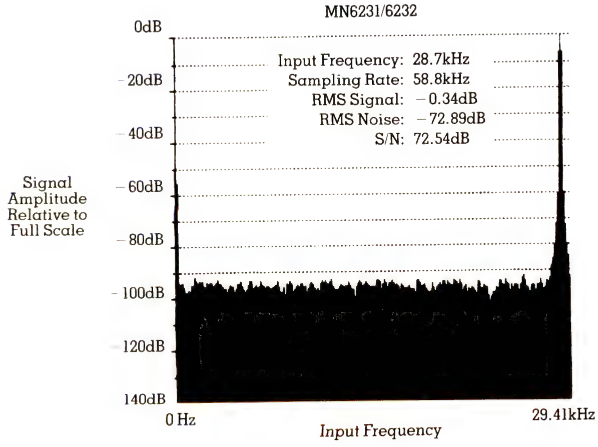
Single Package Sampling A/D's
User Transparent T/H Amplifiers
Frequency Domain (FFT) Testing
High Sampling Rates/Resolution:
  MN6290/6291: 20kHz 16 Bits
  MN6231/6232: 50kHz 12 Bits
  MN6227/6228: 33kHz 12 Bits
MIL-STD-883 Screening

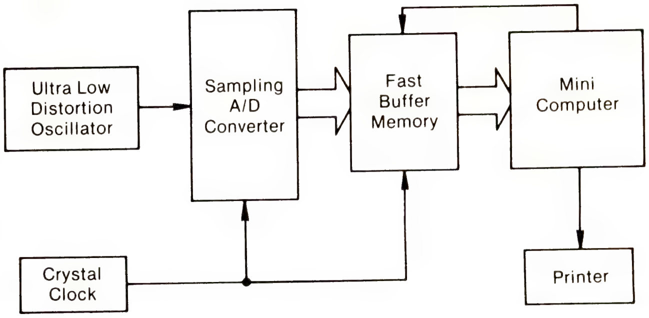
For you, we've expanded our line of FFT-tested, high-speed, sampling A/D converters with two new 16-bit models: MN6290 and MN6291. Like our entire MN6000 Series, these new devices mate a track-and-hold amplifier (T/H) with a high-speed, high-resolution, A/D converter in a single DIP package. The T/H is completely transparent, eliminating the hassle of evaluating T/H specs that are difficult to understand and often don't relate.

All MN6000 devices accurately sample and digitize dynamic input signals with frequency components up to the Nyquist frequency (one-half the sampling rate). They are ideal for radar, sonar, spectrum and vibration analysis, voice and signature recognition, and other contemporary DSP applications. All come with full frequency-domain performance specifications, which are critical to designing for these applications.

Micro Networks was the first to apply FFT testing to A/D converters. We recognized that this would be the key to specifying A/D's for emerging DSP applications. In our frequency-domain testing, sampling A/D's operate in a manner that simulates a digital spectrum analyzer with a known low-distortion input signal. The output spectra yield precise, practical measurements of signal level, noise level, signal-to-noise ratio, harmonic distortion, and input bandwidth, giving you the performance specifications you need to design to your application. Our testing clearly demonstrates the ability of our MN6000 Series devices to maintain near-ideal signal-to-noise ratios independent of increasing analog input frequencies.







Frequency-Domain Testing of A/D Converters

All MN6000 Series devices are packaged in standard ceramic DIP's and are available fully specified for −55°C to +125°C with MIL-STD-883 screening. 12-bit models contain full 8 or 16-bit µP interfaces. Select the device that best meets your design requirements.

Part Number	Input Range	Minimum Sampling Rate	Minimum Input Bandwidth (Note 1)	SNR (Note 2)	Harmonics
12-Bit Resolution					
MN6227	10V	33kHz	16.5kHz	70dB	−80dB
MN6228	20V	33kHz	16.5kHz	70dB	−80dB
MN6231	10V	50kHz	25kHz	70dB	−80dB
MN6232	20V	50kHz	25kHz	70dB	−80dB
16-Bit Resolution					
MN6290	10V	20kHz	10kHz	84dB	−88dB
MN6291	20V	20kHz	10kHz	84dB	−88dB

1. Input bandwidth for which SNR and harmonic specs are guaranteed when sampling at the minimum guaranteed rate.
2. Signal-to-noise ratio (r.m.s. to r.m.s.) with full-scale (0dB) input.

For detailed information on MN6290/6291 or other high-speed sampling A/D's in our expanding line, send for our comprehensive data sheets. For rapid response, call Russ Mullet at Ext. 208.

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Worcester, Massachusetts 01606
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CIRCLE NO 160

zener-zapped current-cancellation circuit reduce the input bias current to only 600 pA max at 125°C and 100 pA max at 25°C. The maximum input-offset voltage and drift are 120 μV and 1.5 μV/°C. The minimum PSR (power-supply rejection) and CMR (common-mode rejection) are 114 dB. The PM-1008 draws only 600 μA of supply current when operating with ±15V supplies at 25°C; you can operate the op amp with supplies in the range from ±2.5 to ±15V. The typical noise-voltage density at 10 Hz is 17 nV/√Hz. External terminals let you compensate the op amp for each application by using a single capacitor. The device is available in an 8-pin TO-99 can and an 8-pin plastic DIP. From $3.10 (100).

Precision Monolithics Inc, Box 58020, Santa Clara, CA 95052. Phone (408) 727-9222. TWX 310-371-9541.

Circle No 375

1200-BPS MODEM

- *Implements Bell 212A/CCITT V.22 modems*
- *Fabricated in silicon-gate CMOS*

The XR-2130 chip implements a 1200-bps modem that meets the requirements of Bell 212A/CCITT V.22. Fabricated in silicon-gate CMOS technology and operating on ±5V power supplies, the device provides a bus-structured interface suitable for control by standard microcontrollers such as Zilog's CMOS Z8. The chip's coherent demodulator—based on a Costas loop—provides a bit-error rate of less than 10^5 for worst-case line conditions (CO), and S/N ratios as low as 11 dB. Its digital echo-modulation techniques minimize interference by the local transmitter, producing an input dynamic range of 45 dB. The chip also features DTMF dialing; complete call-progress monitoring; and analog, digital, and remote-digital loopback test modes. An evaluation board is available. The modem comes in a 28-pin DIP, a 28-pin PLCC, or a 32-pin surface-mount package. $21 (100). Delivery, six to eight weeks ARO.

Exar Corp, Box 49007, San Jose, CA 95161. Phone (408) 434-6400. TWX 910-339-9233.

Circle No 376

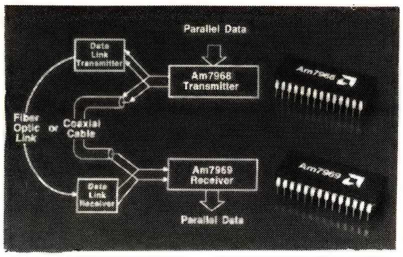
COMM CHIPS

- *56M-bps data throughput*
- *8-, 9-, or 10-bit data words*

The Am7968 transmitter and Am7969 receiver make up the Taxi (transparent asynchronous transmitter-receiver interface) chip set, which handles high-speed digital serial communications over fiber-optic or coaxial lines. The Am7968 accepts parallel data and transmits it in an asynchronous serial format. At the other end, the Am7969 con-

Color by

CalComp's new graphics subsystem pumps new excitement into Micro Vax II, turning up to four terminals into high performance, high resolution graphic workstations. Brooktree® RAMDACs pump out the color, enabling CalComp to do it all on a single board.



verts the data back to the bit-parallel, byte-serial format. Each device has 12 interface pins, which allow it to operate with 8-, 9-, or 10-bit data words. (You can cascade the chips to handle wider data words.) It is currently capable of 56M bps (a 70-MHz clock rate); the vendor plans to offer a 100M-bps version (a 125-MHz clock rate) later this year. The devices operate on 5V and come in 28-pin ceramic DIPs. $58/pair (100).

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 732-2400.

Circle No 377

MOTOR DRIVER

- *Drives two independent unipolar stepper motors*
- *Has 60V/1A output capability*

The UAA2081DP IC provides full- and half-step drive for two independent unipolar stepper motors. The device controls both speed and direction by means of five LSTTL/CMOS-compatible control lines, which are suitable for direct connection to a microcontroller. It uses command words, each comprising two 3-bit words, to control the stepper motors. To provide a high degree of noise immunity, the control inputs feature glitch filtering, which prevents them from responding to pulses of less than 200 nsec in duration. Each output stage has a voltage capability of 60V and a maximum output current of 1A (into a single motor phase) or 700 mA (into two motor phases). The output current for each motor is programmed with an external resistor. Freewheel diodes, with a leadout for their common-cathode connection, are included in the output stages. The device comes in a 24-pin DIP. $7.20 (1000).

Thomson Semiconducteurs, 45 Ave de l'Europe, 78140 Velizy, France. Phone (1) 39469719. TLX 204780.

Circle No 378

Thomson Components-Mostek Corp, 1310 Electronics Dr, Carrollton, TX 75006. Phone (214) 466-6000. TLX 730643.

Circle No 379

SCSI CONTROLLER

- *Transfers data at 4M bytes/sec*
- *Dissipates only 75 mW typ*

You can directly substitute the L5380 asynchronous SCSI-controller chip for existing devices without modifying your circuit board. Sub-

Brooktree®

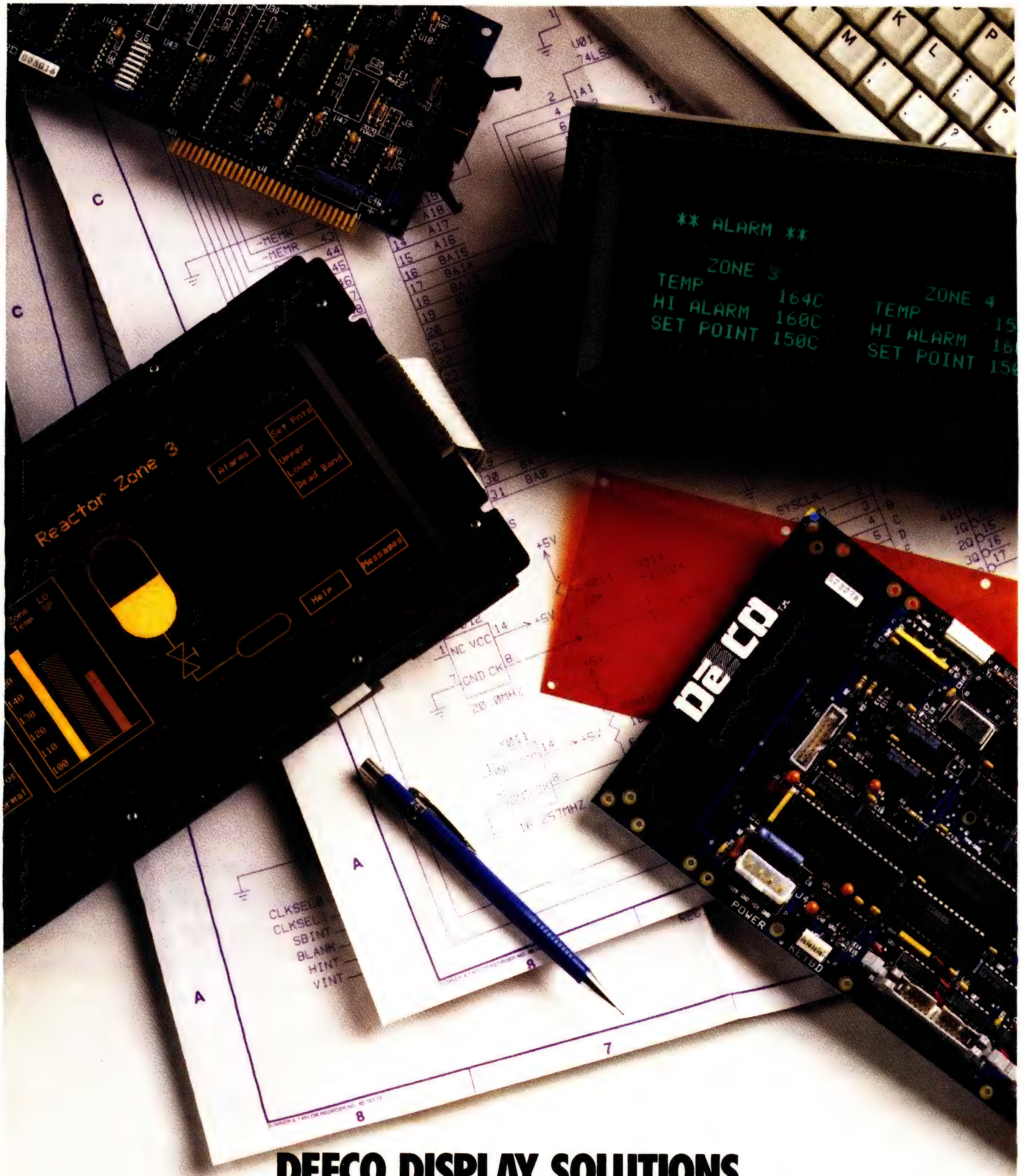
Brooktree Bt458. Triple 8-bit RAMDAC with 256 color lookup table. Available in speeds from 80 MHz to 135 MHz. TTL compatible.

CalComp Formula 1™ 1280 x 1024 resolution graphics subsystem for the DEC Micro Vax II. Displays 256 colors from a 16.8 million color palette.

Brooktree Corporation, 9950 Barnes Canyon Road, San Diego, California 92121. 1-800-VIDEO IC or 1-800-422-9040, in California.

Micro Vax II is a registered trademark of Digital Equipment Corp. Formula 1 is a CalComp trademark.

CIRCLE NO 20



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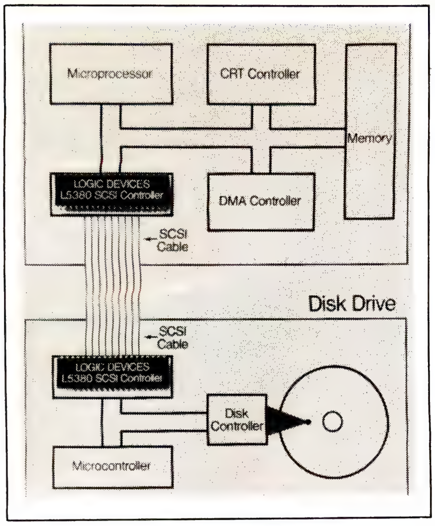
Digital Electronics Corporation, 31047 Genstar Road, Hayward, CA 94544-7831 (415) 471-4700

CIRCLE NO 161



stituting the CMOS part gives you 2.5 times the speed (4M bytes/sec) and one tenth the power dissipation (75 mW typ) of the NMOS device it replaces. The L5380 implements the asynchronous SCSI interface as defined by the ANSI X3T9.2 committee in the X3.131-1986 document. Further, the part works in both the initiator and the target modes, so you can use it in both the computer and the disk drive. It comes in a 40-pin plastic DIP or a 44-pin PLCC and is graded for 2-MHz or 4-MHz operation. 2-MHz version in a DIP, $8.53; 4-MHz version in a PLCC, $18.71 (100).

Logic Devices Inc, 628 E Evelyn Ave, Sunnyvale, CA 94086. Phone (408) 720-8630.

Circle No 380

DIALER CHIP

- *Supports LD or DTMF dialing*
- *Has last-number redial, repertory dialing stores*

The MA545 is a CMOS dialer chip featuring loop-disconnect (LD) or DTMF keypad dialing, a 24-digit last-number redial store, and ten 24-digit repertory dialing stores. You can select between LD and DTMF dialing via the telephone's keypad. The chip also has selectable 2:1 or 3:2 make/break ratios and selectable 500- or 800-msec interdigit pauses. You can obtain options

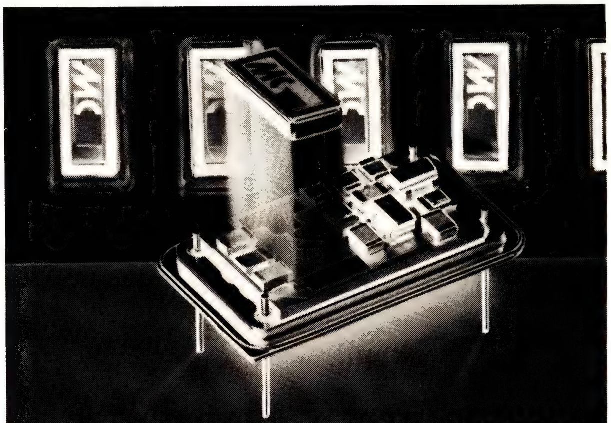
TRIMMERS

BI means standard trimmers made special for you.

We offer a broad line of standard rectangular and square multiturn, single turn, and surface mount trimmers. But we feature something more—a special knack for solving your applications problems through modified components and packaging, including tape and reel, tube and ammo pack. When you design in Beckman Industrial Corp. products, you not only get 45 years of quality leadership, you get custom attention to your needs as well. And you don't have to ask for it; it's standard.

For applications assistance or the BI Resistive Products Short Form Catalog, call **(714) 447-2700.**

Beckman Industrial™
4141 Palm St., Fullerton, CA 92635
CIRCLE NO 21


QUARTZ CRYSTALS FOR SURFACE MOUNT

Micro Crystal high quality miniature quartz crystals for surface mounting are tailored to advanced microelectronics requirements.
- Mountable by vapor phase or infrared solder reflow, or wave soldering at 260° C for 20 sec.
- Available in 16 mm tape, double pitch, on standard 7" reel (up to 1k pieces per reel)
- Frequency range from 10 kHz to 4 MHz and 8 MHz to 24 MHz.

MICRO CRYSTAL/DIV. OF ETA
212/505-5340
ETA INDUSTRIES, INC.
35 East 21st St., New York, NY 10010
CIRCLE NO 22

Ask For Our High-Speed Data Links And You'll Get A Fast Response.

Siecor not only offers the most advanced 50, 125 and 200 Mbd data links for FDDI and other high-speed applications. We also stock them in plentiful supply, so they're available for testing at a moment's notice. In fact, we'll get them to you overnight when necessary.

It's also easy to get large quantities once you've seen our excellent results. And we're certain you'll order our data links for a variety of reasons. Such as our excellent receiver sensitivity. Our ability to use a single power source. Our small, compact size. And the fact that all our data links are EMI shielded, thoroughly tested and proven in applications from 5 to 200 Mbd.

After you see how beautifully our high-speed data links perform, you'll want to try our other electro-optic components, too. Including our SAW filter-based clock recovery modules, clock oscillators, fiber optic switches, fiber optic modems (RS232, RS422 and TTL) and parallel/serial converters.

All Siecor components are competitively priced, so there's nothing to hold you back from calling us for evaluation quantities. And nothing to hold us up in getting them to you. Just call 919/549-6571. Or write Siecor Corporation,

Electro-Optic Products,
Post Office Box 13625,
Research Triangle Park,
North Carolina
27709-3625.

SIECOR

CIRCLE NO 162

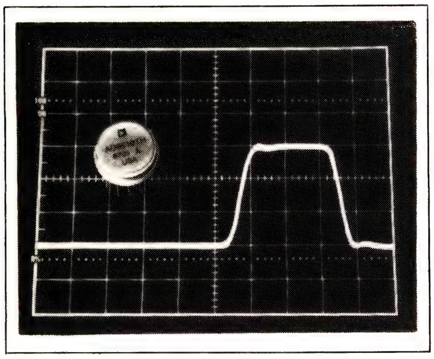
that make the LD dialing function suitable for use in Sweden, Denmark, Norway, and New Zealand. The chip's current consumption is low enough (typically less than 1 μA with the telephone on hook) that you can supply current to the dialer chip by leaking current from the telephone line. The dialer is available in an 18- or 20-pin DIP. The 20-pin DIP includes an amplifier suitable for use as a tone-filtering circuit. The MA545 is compatible with the company's MA540, MA526, and MA527 Series dialer chips, so you can use a single pc-board design for a range of telephones. £3.70 (100).

Marconi Electronic Devices Ltd, Doddington Rd, Lincoln LN6 3LF, UK. Phone (0522) 688121. TLX 56380.

Circle No 381

Marconi Electronic Devices Inc, 45 Davids Dr, Hauppauge, NY 11788. Phone (516) 231-7710. TLX 275801.

Circle No 382



OP AMP

- *100-MHz bandwidth*
- *3500V/μsec slew rate*

The AD9610 is a hybrid transimpedance op amp. Using current feedback instead of voltage feedback, the amplifier provides bandwidth that is relatively independent of closed-loop gain: 100 MHz at unity gain, 95 MHz at a gain of −10, and 75 MHz at a gain of −20. In addition, different gains have little effect on the op amp's 3.5-nsec rise

BI means standard networks made special for you.

NETWORKS

We offer a broad line of RESNET® dual in-line thick and thin film, and single in-line thick film resistor networks. But we feature something more—a custom capability for special resistance values, combinations and packages to meet your requirements. When you design in Beckman Industrial Corp. products, you not only get 45 years of quality leadership, you get custom attention to your needs as well. And you don't have to ask for it; it's standard.

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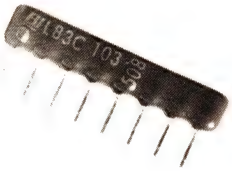
CIRCLE NO 23



Technipower "Mil-Qual" Triple Output Switching Power Supplies

Sealed or Field Repairable

The efficiency and size of a switcher, the output of a linear — all in a compact package! Available in AC/DC and DC/DC models, these "Mil-Qual" units are designed for severe shock and harsh environments. They feature a Mil-type input/output connector along with specially developed EMI/RFI filter circuitry. MTBF is 100,000 plus hours. Efficiency is 80%. Full power is provided at max operating temp., to 95°C, no derating.

Choose from 20 models which meet Mil-704, Mil-901 and other standards, have transient protection plus power ranges from 20 to 300W. *5 year warranty.* Send for details.

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CIRCLE NO 24

MOTOROLA from HAMILTON/AVNET

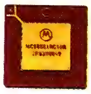
MC68020 KIT

FOR A LIMITED TIME ONLY, EXCLUSIVELY FROM HAMILTON/AVNET

Motorola's complete MC68020KIT 32-bit Design Kit lets you evaluate the high-performance 32-bit Motorola microprocessor family at a reasonable cost: just $399. And it has everything you need to begin designing high performance multiuser business systems, engineering workstations, industrial controllers, communications controllers, graphics controllers and more.

Each kit contains 16.67 MHz versions of the:

MC68020 32-bit Microprocessor with a complete 32-bit internal architecture, complete 32-bit external implementation, on-chip instruction cache, coprocessor interface and low power consumption HCMOS technology.



MC68881 Floating Point Coprocessor, which provides functionality and performance. It fully implements the IEEE 754 Binary Floating Point Specification and provides trigonometrics, hyperbolics, exponentials, logarithmic plus non-trancendental functions.

MC68851 Paged Memory Management Unit. The PMMU translates logical addresses to physical addresses in one clock cycle (less than 45 ns at 16.67 MHz) through the use of an on-chip address translation cache. It provides complete support for multitasking applications, *logical* or physical data caches, virtual machine and multiple bus masters.

You'll also get enough Motorola Static RAMS to build a 32-bit wide external cache for the MC68020, just like the high performance workstations now on the market. Also included in the kit are two low-cost 11-channel (MC145040 and MC145041) CMOS A/D Converters with serial interface ports to provide communication with MPUs and MCUs.

And, since this offer is exclusively from Hamilton/Avnet, we've got still more.

YOU GET COMPLETE DOCUMENTATIC AND HAMILTON/AVNET'S FULL SUPPO

Included in the MC68020KIT is cor plete documentation, with everythir pertaining to the Motorola 32-bit micr processor family, including individu data sheets, users manuals and applicc tion notes for each of the three chips.

You'll also get information on Motorol second generation 32-bit chips, th MC68030 and MC68882, plus 16 articl reprints, 15 brochures, 23 engineering bu letins and a MC68020 microphotograpl

This kit lets you purchase all thre chips and every piece of literature fc less than half the price of the chip alone. Hamilton/Avnet makes it less e pensive and easier for you to desig with the devices that have already cap tured most of the 32-bit MPU applicatior now in the market.

There's only one way you can get MC68020KIT: contact your service repre sentative at your local Hamilton/Avne facility. For the phone number of you nearest Hamilton/Avnet facility, call 1 800-826-0500 (in Canada, 1-800-387 6879; 1-800-387-6849 in Ontario anc Quebec). But they're in limited supply so you've got to call now. Because wher they're gone, they're gone, and at thi price, we can only allow one (1) ki per customer.

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ELECTRONICS
AN AVNET COMPAN

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Sign up for a 10% discount on this already low price by bringing this coupon to the Hamilton/Avnet booth (#2530). This offer expires at the end of the last day of the show.

EDN91787

NAME ______________________

TITLE ______________________

COMPANY ______________________

ADDRESS ______________________

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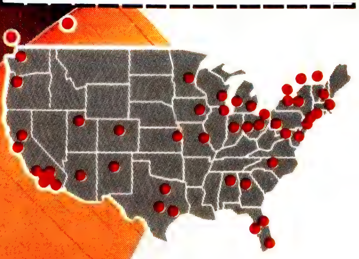
STATE ____________ ZIP ____________

MSTOP ______________________

PHONE ______________________

APPLICATION ______________________

One kit per person.
Available on a first come, first served basis.



and fall times, its 18-nsec settling time (to within ±0.1%), and its 3500V/μsec slew rate. Laser trimming reduces the input offset voltage to ±0.3 mV; the V_{OS} drift is 4 μV/°C. The equivalent input noise over the frequency range from 5 to 150 MHz is 0.7 $nV/\sqrt{Hz}$ typ and 23 $pA/\sqrt{Hz}$ typ. The amplifier has internal frequency compensation and an internal 1.5-kΩ feedback resistor; you add one resistor to set the closed-loop gain. The AD9610 comes in a 12-pin TO-8 metal can, operates with ±15V supplies, and dissipates 630 mW typ. Industrial-temperature version, $49.88; military-temperature version, $79 (100).

Analog Devices Inc, Box 9106, Norwood, MA 02062. Phone (617) 329-4700. TWX 710-394-6577.

Circle No 383

MULTIPLEXER

- *±10.8 to ±22V supply range*
- *20-nA leakage current at 85°C*

Compared with the existing 508A types, the DGP508A 8-channel analog multiplexer offers tightened limits on critical parameters. Its improved capability for automatic testing allows the manufacturer to test 100% of the production units for parameters such as the variation of channel-switching times and on-resistance (within a single device), and charge injection. The improved specs include a wider supply range (±10.8 to ±22V) and lower source- and drain-leakage currents (2 nA at 25°C; 20 nA at 85°C). The parts come in 16-pin plastic or ceramic DIPs specified for operation over the industrial or military temperature ranges. From $6.55 to $21.95 (100).

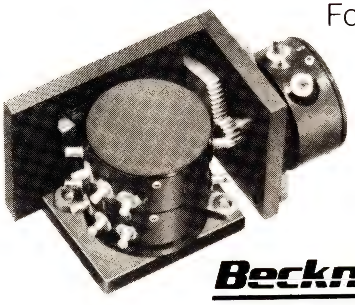
Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 384

BI means standard pots/dials made special for you.

We offer a broad line of standard HELIPOT® single as well as 10-turn pots, and analog as well as digital turns-counting dials. But we feature something more—a special design expertise that gets to the heart of your unique requirements, including servo subsystems, precision electro-mechanical assemblies and other highly specialized applications. When you design in Beckman Industrial Corp. products, you not only get 45 years of quality leadership, you get custom attention to your needs as well. And you don't have to ask for it; it's standard.

For applications assistance or the **BI** Resistive Products Short Form Catalog, call **(714) 447-2700.**



Beckman Industrial™
4141 Palm St., Fullerton, CA 92635
CIRCLE NO 25

POTS/DIALS

FIBER OPTICS

By Lightwave Communications, Inc.

- 8, 16, 32, 64 Channels
- Up to 64 Kb/s
- Full and Half Duplex
- Rack Mount Frame

RS-232 Multiplexers

- Full Duplex
- Half Duplex
- With/Without Clock
- Up to 2 Km

RS-422 Modems

Send this ad to Lightwave Communications, Inc. for more information on RS-232 Modems — Video Links — Fiber Optic Cable Assemblies
EDN91787

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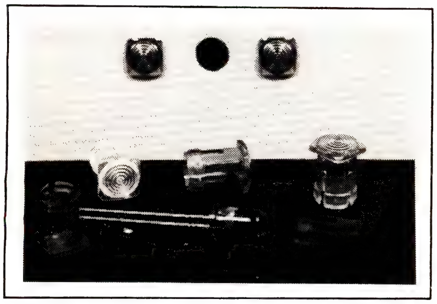
Company ______
Address ______
City, State, Zip ______
Phone ______

Lightwave Communications, Inc.
650 Danbury Road, Ridgefield CT 06877
203 • 438-3591
CIRCLE NO 26



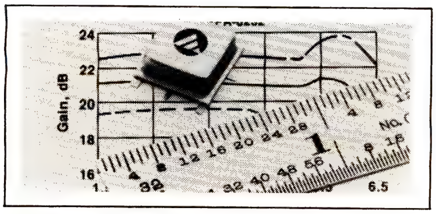
LED LENS

- *Mounts in a round hole*
- *No tools needed for installation*

The SQB 400 Series lens mount has a square lens, but mounts in a round panel hole. Its low-profile lens design prevents it from being turned or easily misaligned. The lens is designed for front-panel mounting in a 0.25-in. round hole on a 0.375-in. center. You can install it without tools—you simply snap the lens mount through the panel and insert the LED (T1-¾) from the rear. The lens mount is suitable for panels with thicknesses of 0.0312 to 0.25 in. Its viewing angle is 180°, and it's available in six colors. $0.09 (10,000).

Visual Communications Co Inc, 7920-G Arjons Dr, San Diego, CA 92126. Phone (800) 522-5546; in CA, (619) 549-6900.

Circle No 351



AMPLIFIER

- *Features a 2- to 6-GHz frequency range*
- *Housed in a package ⅜-in. high*

The Model PPA-6232 microwave surface-mount amplifier has a minimum gain of 18 dB (20 dB typ) over a 2- to 6-GHz frequency range. Specifications include a maximum noise figure of 5.5 dB (4.3 dB typ), +17 dBm min, 1-dB compressed output power, and a 2:1 guaranteed maximum input and output VSWR. All specs apply over a 0 to 50°C operating range. Slightly reduced specifications apply over a −55 to +85°C range. The PPA-6232 is housed in a ⅜-in^2 package that can maximize component density on microstrip pc boards. $450.

Avantek Inc, 3175 Bowers Ave, Santa Clara, CA 95054. Phone (408) 943-4296.

Circle No 352

ATTENUATORS

- *Provide precision tone or volume control*
- *Low-profile package*

Designed for precision tone- or volume-control applications, the Stepped Attenuators feature a low-profile package that requires little more than 0.25 in. behind the panel. The units come in −50-, −60-, and −70-dB tapers with 22 detent positions. A linear taper version with 11 detent positions is also available. The parts' standard resistance values range from 10 to 100 kΩ. Their error is lower than 0.5 dB at each step, and their resistance tolerance is ±5%. The wiper, shaft, and resistance element can withstand 200,000 revolutions. A wide variety of shaft styles is available, as are pc-board or solder-lug-type terminals and several mounting options. From $9.69 (1000). Delivery, 12 weeks ARO.

Bourns Inc, 1200 Columbia Ave, Riverside, CA 92507. Phone (714) 781-5050. TWX 910-332-1252.

Circle No 353

ANOTHER FIRST FROM OAE

One OMNI can program *and test* everything from micro-power PLDs to fully populated PC boards.

The Ultimate Programmer. OAE has drawn upon 12 years of research and manufacturing experience to develop the ultimate software configured programmer.

The OMNI combines ***high-power, high-resolution,*** software configured pin drivers with a huge database of PROMs, EPROMs, EEPROMs, EAROMs, PLDs, microprocessors and ASICs (Application Specific ICs) to eliminate costly and outdated configuration modules and programming adapters.

The OMNI's patented pin drivers let you program and test more devices than any other system. The OMNI provides ***unlimited support*** from bipolar diode arrays to micro-power CMOS PLDs like the HPL-16LC8. And now you can program hybrid modules and complete PC boards with the OMNI 64.

Want to enter your own test and programming parameters? Just use the optional parametric editor to screen every device programmed to your own specifications.

- 100% Software Configured.
- Fast, high voltage, high current pin drivers can supply +-1.5A continuous to +-10A peak at each pin.
- Over 4,000 steps of voltage and current resolution and *sub*-nanosecond timing resolution.
- 100% laser trimmed for high speed and accuracy. No calibration is ever required.
- Plug compatible with over 350 different computers.
- Add over 20,000 new devices by modem, diskette, or RLB module.
- The OMNI 64 supports ALL package types, including SOs, LCCs, PLCCs, PGAs, DIPs, SIPs, etc.
- ***Free library updates for 2 years.***
- Small, portable and easy to use.

Prices start at just $3250.

Oliver Advanced Engineering, Inc.
320 West Arden Street
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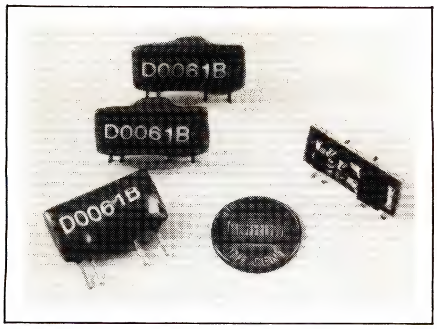
TWX (510) 600-8099

CIRCLE NO 164



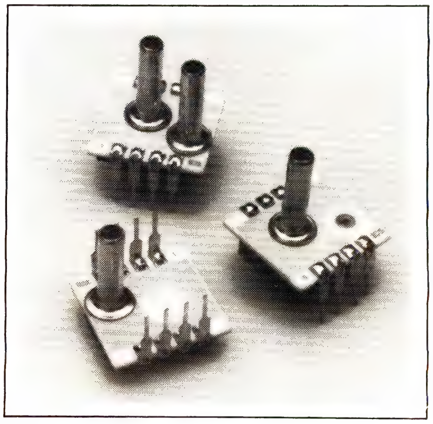
OUTPUT MODULES

- *Switch 60V in 50 µsec*
- *Handle 5A surge currents*

The DO 061 dc-output SIP (single in-line package) modules switch loads of 60V at 1A as fast as 50 µsec. Two versions are available. The 061A has an on-state input control range of 3 to 9V dc and currents of 7.4 to 30 mA. The turn-on and turn-off times are 50 µsec. The 061B has an on-state control range of 1.6 to 9V dc at currents of 2 to 30 mA; the turn-on and turn-off times are 50 and 150 µsec, respectively. Both units can handle loads of 3 to 60V dc at currents of 20 mA to 1A, with an on-state voltage drop of 1.5V dc max. The units can handle 5A surge currents for 1 sec. They operate over −30 to +80°C (above 60°C, they're derated 10 mA/°C). If you're going to switch inductive loads, it's best to use diode suppression across the load. 061A and 061B, each $4.35 (1000). Delivery, four to six weeks ARO.

International Rectifier, Crydom Div, 1521 E Grand Ave, El Segundo, CA 90245. Phone (800) 245-5549; in CA, (213) 322-4987.

Circle No 354



PRESSURE SENSOR

- *Operates with a voltage or current source*
- *Has ±0.1% accuracy*

The Model 410 is a general-purpose piezoresistive pressure sensor that is housed in a DIP for easy mounting on a pc board. It uses a 5-pin open-bridge resistor format, so it can be excited with either a voltage or a current source. It comes in gauge, absolute-, and differential-pressure versions, each of which is available in two performance grades: 0 to 2 psi and 0 to 100 psi. The gauge version is compatible with a wide range of liquid and gas

BASU

NEW
68020/SCSI
Combo

Model CPU20 with Dual-Ported, One kbyte, SRAM Mail Box for Multiprocessor Applications

Standard Features
32 Bit-Wide Address & Data Range.
Clock Rates = 12.5 & 16.
One Mbyte (4 Mbyte) DRAM with Parity Option.
One Mbyte EPROM Space.
SCSI Interface.
Two Serial Ports
• RS 232C
One Parallel Port
• 24-Bit Counter/Timer
NOVRAM
• An SRAM that saves special or user-definable variables, even at Power Fail or Power Down.

Special Features
Four LEDs.
Four-Digit Programmable Alphanumeric Display.
Four Soft Touch Control Buttons with LEDs.
EPROM Space = One 32-Pin Socket.

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Ph. (408) 727-1932

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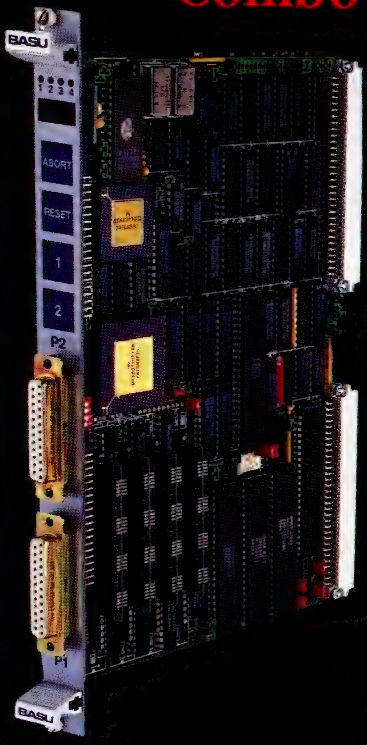
D-8000 Munich 80, Ph. (89)63801-0
TLX 5213288 mibad

Ask about our soon-to-be announced CPU21 & 22
(68020 w/Dual Ported SRAM or DRAM)



Options
FPU (MC68881) & PMMU Piggy Back

Operating Systems
OS-9 (™Microware)
PDOS (™Eyring)
UNIPLUS+ (™Unisoft)

VMEbus

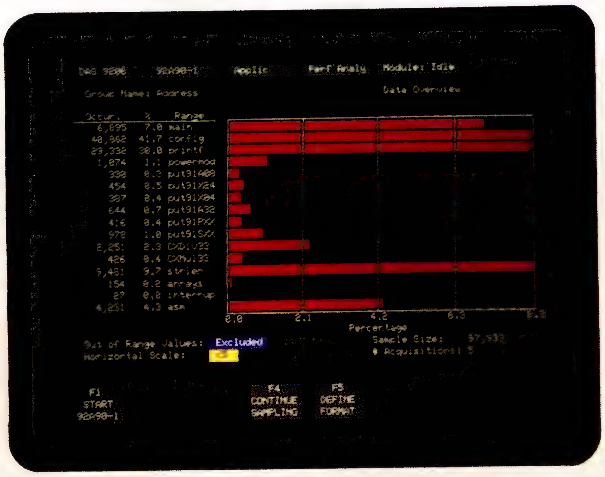
CIRCLE NO 27

A FIRST FROM TEKTRONIX

TURN BACK THE CLOCK ON MICROPROCESSOR PROBLEMS!

Now see what your hardware and software are really doing, in real time, without waiting for problems to repeat. Nothing else comes close to tools like these in Tek's DAS9200 Digital Analysis System:

- **Register deduction.** Acquire and disassemble up to 32K samples of processor activity. The DAS9200 can show you the contents of the register before the problem occurred!
- **Stack deduction.** Similarly, you can scroll through changes in a stack model and end the painstaking process of tracking contents by hand.
- **Data display.** Watch as your variable space is modified by the software. No more trial-and-error to it—you can see when variables get clobbered.



```
DAS 9200    92A90-1    Applic    Perf Analy    Module: Idle
Group Name: Address                            Data Overview

 Occur.     %    Range
  6,895   7.0   main
 40,862  41.7   config
 29,332  30.0   printf
  1,074   1.1   powermod
    330   0.3   put91A08
    454   0.5   put91X24
    387   0.4   put91X04
    644   0.7   put91A32
    416   0.4   put91PXX
    978   1.0   put91SXX
  2,251   2.3   CXDiv33
    426   0.4   CXMul33
  9,481   9.7   strlen
    154   0.2   arrays
     27   0.0   interrup
  4,231   4.3   asm

Out of Range Values:  Excluded            Sample Size:     97,932
Horizontal Scale:                         # Acquisitions:  5
```

- **Subroutine trace.** Follow the flow of high-level language subroutines using address symbolics.
- **Performance analysis.** Plot execution times, times within subroutines, and more, for an invaluable graphic overview.

Monitor and integrate up to six 8-, 16- or 32-bit micros at once! That's just one of many other ways the DAS9200 helps you beat the clock in system design. To learn more, contact your local Tek representative. Or call:

1-800-245-2036.
In Oregon, 231-1220.

Circle 100 for Literature

Circle 101 for Sales Contact

Tektronix®
COMMITTED TO EXCELLENCE

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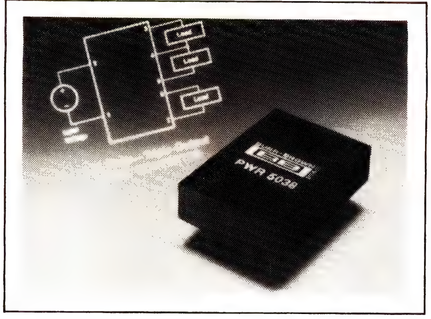
media. Various lead and pressure-tube configurations are available for customizing the package for specific applications. The sensor has an accuracy of ±0.1%, and its typical output span is 100 mV. $8 (OEM qty).

IC Sensors Inc, 1701 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1800.

Circle No 355

DC/DC CONVERTER

- *−25 to +85°C operating range*
- *Features input and output filtering*



The PWR5038 2.75W dc/dc converter provides outputs of 5 and ±15V from a 5V input. The 5V output is regulated and guaranteed to maintain the TTL supply level over specified temperature, line, and load conditions. Isolation between outputs and between input and output is 500V dc. The barrier leakage current (100% tested at 240V dc) equals 5 μA. This converter features input and output filtering, 6-sided shielding, input overvoltage protection, and output short-circuit protection. The operating temperature range is −25 to +85°C. All units are barrier-voltage tested to the requirements of UL544, VDE750, and CSA22.2. $26 (1000).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491. TWX 910-952-1111.

Circle No 356

POWER SUPPLY

- *Provides 200A at 5V*
- *Includes 2-stage overtemperature protection*

The Model SA1000-3104 is a 1-kW switchmode power supply that delivers 5V at currents as high as 200A. You can adjust the output voltage by ±2% with a potentiometer, or you can digitally program the output voltage to between 4.2 to 5.75V. The supply's line regulation is 10 mV max over the full operating input-voltage range, and its zero- to full-load regulation is 20 mV max. The power supply operates from line input voltages ranging from either 90 to 135V or 180 to 265V, at a frequency of between 47 and 63 Hz. Its thermal protection includes a high-temperature alarm output that is activated at 50±5°C, as well as an overtemperature alarm output that is activated when the power-supply temperature exceeds 75±5°C. The

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Lockheed's Environmental Test Laboratory provides complete environmental, electromagnetic interference/compatibility and stress screening services on a 24-hour-per-day basis. All at one location.

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CIRCLE NO 28

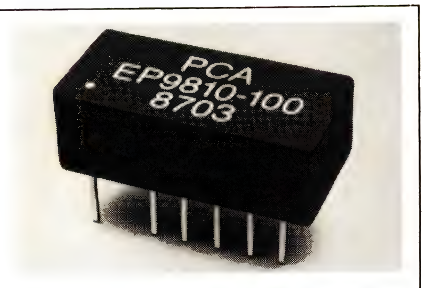
supply automatically shuts down vithin 10 to 30 sec of an overtemperature alarm. It also provides output overvoltage and overcurrent protection. For applications requir-ng more than 200A, you can add lave units to the power supply. The SA1000-3104 measures 8×4.5×11 n. From approximately £500.

Astec Europe, High St, Wollaston, Stourbridge, W Midlands BY8 4PG, UK. Phone (0384) 396171. TLX 337482.

Circle No 357

Astec (USA) Ltd, 2880 San Thomas Expressway, Suite 200, Santa Clara, CA 95051. Phone (408) 748-1200. TLX 6839191.

Circle No 358



DELAY LINES

- *Inputs and outputs feature Schottky inverter buffers*
- *Offer delays to 1000 nsec*

The EP9810 Series active delay lines provide five equally spaced taps. The 33 members in the series cover total delay values from 25 to 1000 nsec, ±5% or 2 nsec, whichever is greater. The delay-line input and the five output taps are buffered by a Schottky inverter. The output rise time is 4 nsec max for units with delays less than or equal to 500 nsec, and 5 nsec for units with greater delays. The units are housed in 14-pin DIPs and operate over the 0 to 70°C range. $1.60 (1000) for the 100-nsec unit. Delivery, stock to six weeks ARO.

PCA Electronics Inc, 16799 Schoenborn St, Sepulveda, CA 91343. Phone (818) 892-0761.

Circle No 359

IEEE-Z

Easiest IEEE 488 board for your PC-
GUARANTEED!

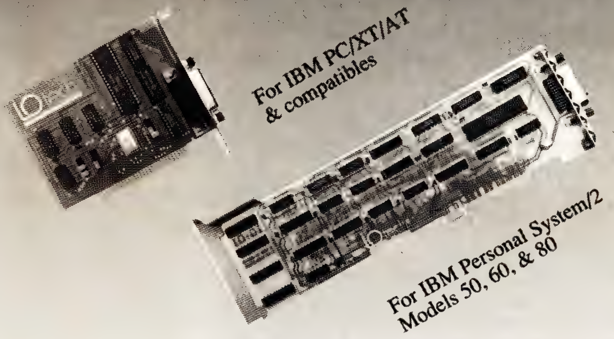
IOtech Personal488*

```
10 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
20 PRINT #1,"ABORT"
30 PRINT #1,"CLEAR 16"
40 PRINT #1,"OUTPUT 16;R3T3X"
```

Typical IEEE board with "CALLS"*

```
10 CLEAR, 50000!
20 IBINIT = 50000!
30 IBINIT2 = IBINIT1 + 3
40 BLOAD "bib.m", IBINIT1
50 CALL IBINIT (IBFIND, IBTRG, IBCLR,
IBPCT, IBSIC, IBLOC, IBPPC, IBPPC,
IBBNA, IBONL, IBRSC, IBSRE, IBSRV,
IBPAD, IBSAD, IBIST, IBDMA, IBEOS,
IBTMO, IBEOT)
60 CALL IBINIT2(IBGTS, IBCAC, IBWAIT,
IBPOKE, IBWRT, IBWRTA, IBCMD,
IBCMDA, IBRD, IBRAD, IBSTOP, IBRPP,
IBRSP, IBDIAG, IBXTRC, IBSTA%,
IBERR%, IBCNT%)
70 A$="DEV16"
80 CALL IBFIND (A$, M195%)
90 CALL IBSIC (BRD0%)
100 IF IBSTA%<0 THEN STOP
110 CALL IBCLR (M195%)
120 IF IBSTA%<0 THEN STOP
130 CMD$="R3T3X"
140 CALL IBWRT (M195%, CMD$)
150 IF IBSTA% <0 THEN STOP
```

√ DOS installable device driver - automatically loads at power up
√ Compatible with all popular languages- never any extra drivers to buy
√ Hewlett-Packard style commands
√ Automatic error and timeout indication
√ Built-in BASIC SRQ program vectoring
√ Lotus Measure, Asyst, & TBASIC compatible
√ DMA data transfers over 300K bytes/sec



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* Both programs clear the bus and configure a digital multimeter.
If you already own a compatible IEEE board our **Driver488** software makes it *IEEE-Z*.

CIRCLE NO 29

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$765*
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$1395*
*100-up quantities

- **Reliable:** Low component count (50-60% fewer parts)
- **Efficient:** Low power requirements (AT and 386, 12 watts max at 5 VDC)
- **Modern design:** Passive backplane (Uses standard size plug-in cards)
- **Fast:** Selectable clock speeds on AT, 386 (AT to 10 MHz, 386 to 16 MHz)
- **Large memory capacities:** XT=640K, AT=1 Meg, 386=16 Meg!

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CIRCLE NO 30

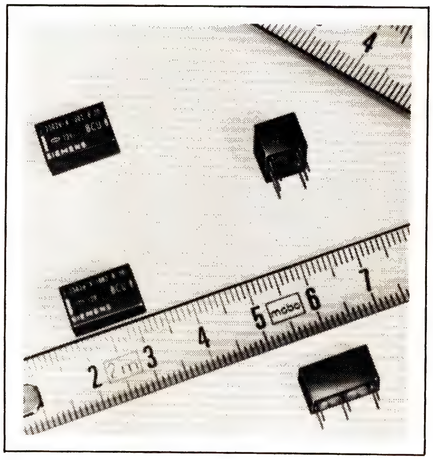
DISPLAYS

- *120° viewing angle (min)*
- *10,000-hour lifetime*

The EL1C dc electroluminescent display panels feature a 25-fL luminance with no more than 30% degradation at 10,000 hours of life. Two basic units are offered, both of which have a 640×200-pixel display area. The EL1C-I000 has a 2-to-1 aspect ratio, and the EL1C-G000 has a 1.4-to-1 aspect ratio. The width of the total package, including display and drivers, measures 0.575 in. The viewing angle equals 120° min, and the operating range measures 0 to 55°C. $385 (5000).

Cherry Electrical Products Corp, 3600 Sunset Ave, Waukegan, IL 60087. Phone (312) 360-3500.

Circle No 360



RELAY

- *Provides 1A switching in a 0.78-cm³ package*
- *Suitable for automatic insertion, solvent cleaning*

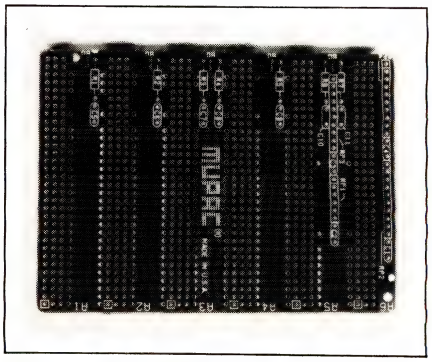
Although they're housed in a package that measures only 12.9×7.62×6.99 mm, the P1 relays have a switching power rating of 30W or 60 VA. The relays have a maximum switching and continuous-current rating of 1A and a switching-voltage rating of 150V dc or 125V ac. At a reduced duty cycle, they can operate at 250V ac or dc. Their contact resistance is 100 mΩ, and they spec a mechanical lifetime of 10^8 operations. The relays have contact-to-coil isolation to 1500V rms, and contact-to-contact isolation to 500V. They are available for nominal coil voltages of 5, 12, 15, and 24V. Their response, changeover, and release times are approximately 1.0, 0.9, and 0.35 msec, respectively. The contact space is encapsulated and the contact atmosphere is protected by a getter. The package has leadouts on a 0.2-in. grid with creepage and clearance spacings that meet the requirements of VDE-0110 (250V ac, 300V dc). The relays are sealed to IP-67 and are suitable for solvent cleaning.

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 361

Siemens Components Inc, 186 Wood Ave S, Iselin, NJ 08830. Phone (201) 321-3400.

Circle No 362

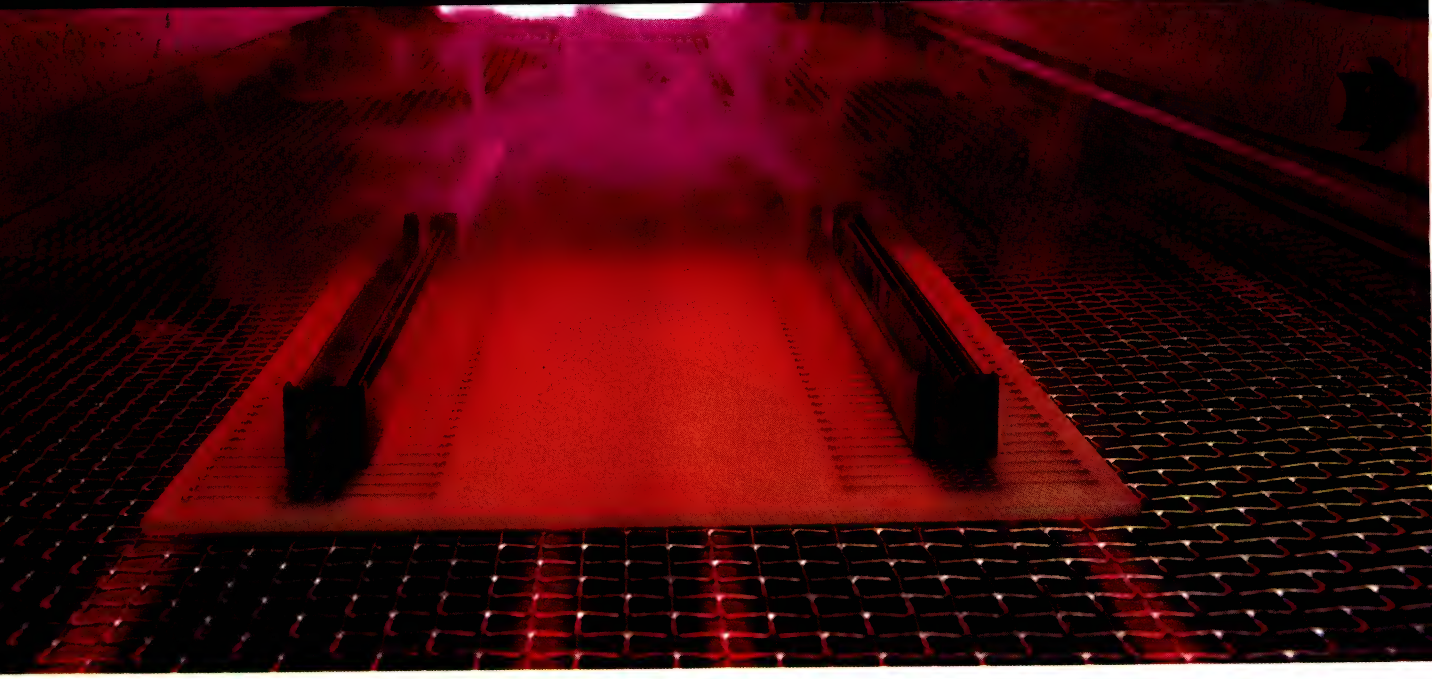


BACKPLANE

- *Available in five sizes*
- *Features 4-layer construction*

This VSB (VME system bus) backplane is designed for use in µP applications in high-performance 32-bit VME systems. It permits faster, more effective memory expansion without overcrowding the J1 backplane, the vendor claims. The backplane is available in 2-, 3-, 4-, 5-, and 6-slot versions. It features 4-layer construction (signal/5V/ground/signal) and is impedance matched. The device plugs onto the standard wire-wrappable tails of

Du Pont RYNITE® beats the heat of vapor phase and wave soldering



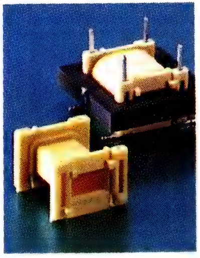
RYNITE® thermoplastic polyester resin withstands 419°F in vapor reflow, 525°F in under-board wave soldering

Component manufacturers are capitalizing on the 435°F (224°C) heat deflection temperature of RYNITE® PET, a polyethylene terephthalate, to beat the heat of wave and vapor phase soldering. RYNITE also offers a UL temperature index of up to 155°C.

Du Pont Connector Systems

Du Pont Connector Systems chose RYNITE over PPS for a new line of slotted header connectors that resist the 419°F of vapor phase soldering and the 525°F of under-board wave soldering. Du Pont Connector Systems selected RYNITE because it exhibits greater elongation and is less abrasive on the mold than PPS.

Midcom bobbin



Midcom, Inc. uses RYNITE for modem transformer bobbins that maintain their shape even under the 525°F heat of underboard wave soldering. Midcom chose RYNITE polyester for better molding performance and for cost savings.

Ericsson connector

L.M. Ericsson replaced PBT polyester with RYNITE® PET in the edge connector (below) because RYNITE® PET polyester withstands vapor phase soldering at 419°F for one full minute. RYNITE also resists the solvents used in cleaning soldered boards.

Get more information by calling for a sales presentation. Or for free literature write to Du Pont Company, Room X50505, Wilmington, DE 19898.

Dial Du Pont First/(302) 999-4592

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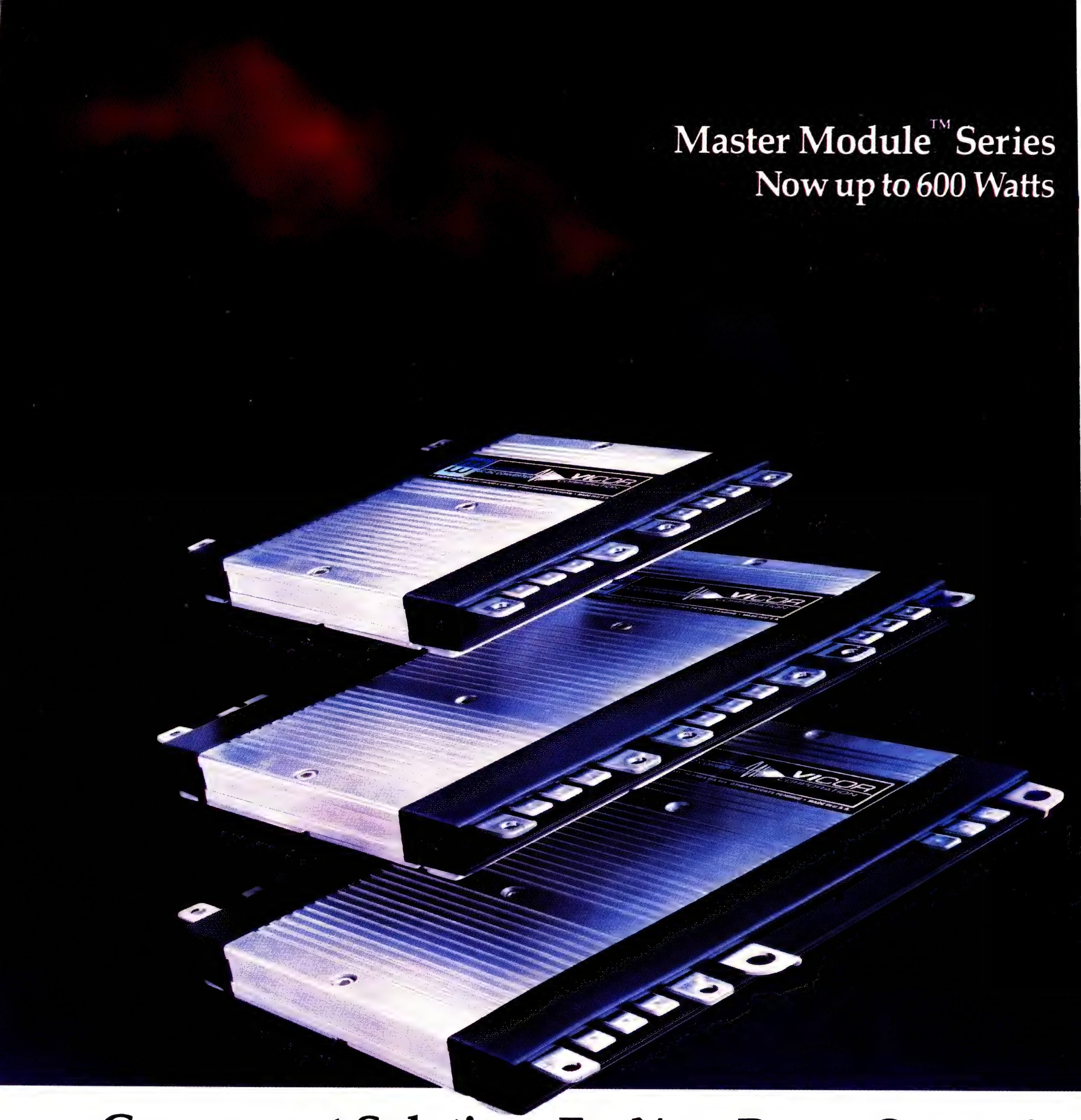

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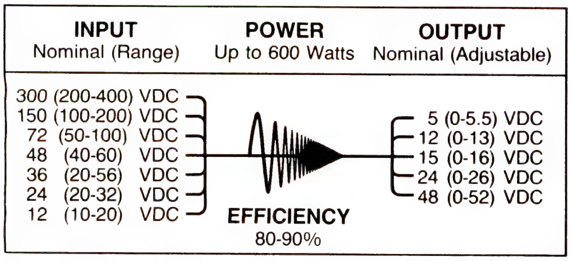

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VI-P000 Series (Dual Output)
up to 400W 4.9″ x 4.9″ x 0.62″

VI-Q000 Series (Dual Output)
up to 600W 7.32″ x 4.9″ x 0.62″

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up to 600W 7.32″ x 4.9″ x 0.62″

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CIRCLE NO 176

the 96-pin DIN connector on the J2 backplane without interfering with the power terminals or harness on the J2. From $123.

Mupac Corp, 10 Mupac Dr, Brockton, MA 02401. Phone (800) 225-0398; in MA, (617) 588-6110. TWX 710-345-8458.

Circle No 363

PRESSURE SENSOR

- *Accuracy of ±0.5%*
- *Can handle most harsh media*

The Model 81 pressure sensor is available in gauge and sealed-gauge ranges of 0 to 5 psi to 0 to 200 psi and in absolute ranges of 0 to 15 psi to 0 to 50 psi. Its accuracy equals 0.5%. The device has a 316 stainless-steel housing structure, which uses an oil column to couple a diffused piezoresistive sensor to a convoluted stainless-steel diaphragm. The diaphragm can withstand most harsh media. Three external resistors (whose values are provided) are needed for temperature compensation and calibration. The output span is nominally 100 mV for a 1.5 mA supply current. The typical bridge resistance is 5 kΩ. $50 (OEM qty). Delivery, stock to six weeks ARO.

IC Sensors Inc, 1701 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1800.

Circle No 364

MOTOR-DESIGN KIT

- *Contains piezoelectric materials*
- *Lets you scale one experiment into many designs*

This Motor/Actuator kit lets you quickly evaluate the feasibility of using piezoelectric materials in your applications. The kit contains 1-layer thin-sheet piezoceramic material, 2-layer laminated piezoceramic stock, a motor/actuator manual, solder, and flux. You can use the elements in the kit to construct bending motors, extension motors, and stack motors. Because the piezoelectric effect is reversible, you can use the same elements to construct piezoelectric sensors and generators. The manual contains practical design techniques to help you model, fabricate, and test a prototype actuator as rapidly as possible. It also provides equations for free deflection, blocked force, resonant frequency, maximum stress, and ca-

The HK68/V2F is a high-performance VME microcomputer with race-bred 32-bit power for real-time applications.
High engine output and economical, dependable performance are just the start of the HK68/V2F's standard equipment:

▪ Up to 25MHz Motorola 68020 CPU ▪ Up to 4MB of on-board DRAM with parity ▪ 128K EPROM ▪ Serial Port ▪ Mailbox interrupt support ▪ VSB compatible memory expansion bus

Optional racing equipment includes 68881 Floating Point Coprocessor and no wait-state DRAM.

HEURIKON CORP.

Take Heurikon's HK68/V2F for a test-lap today.
Call toll-free: 1-800-356-9602 (ext. 405).

3201 Latham Drive ▪ Madison, WI 53713

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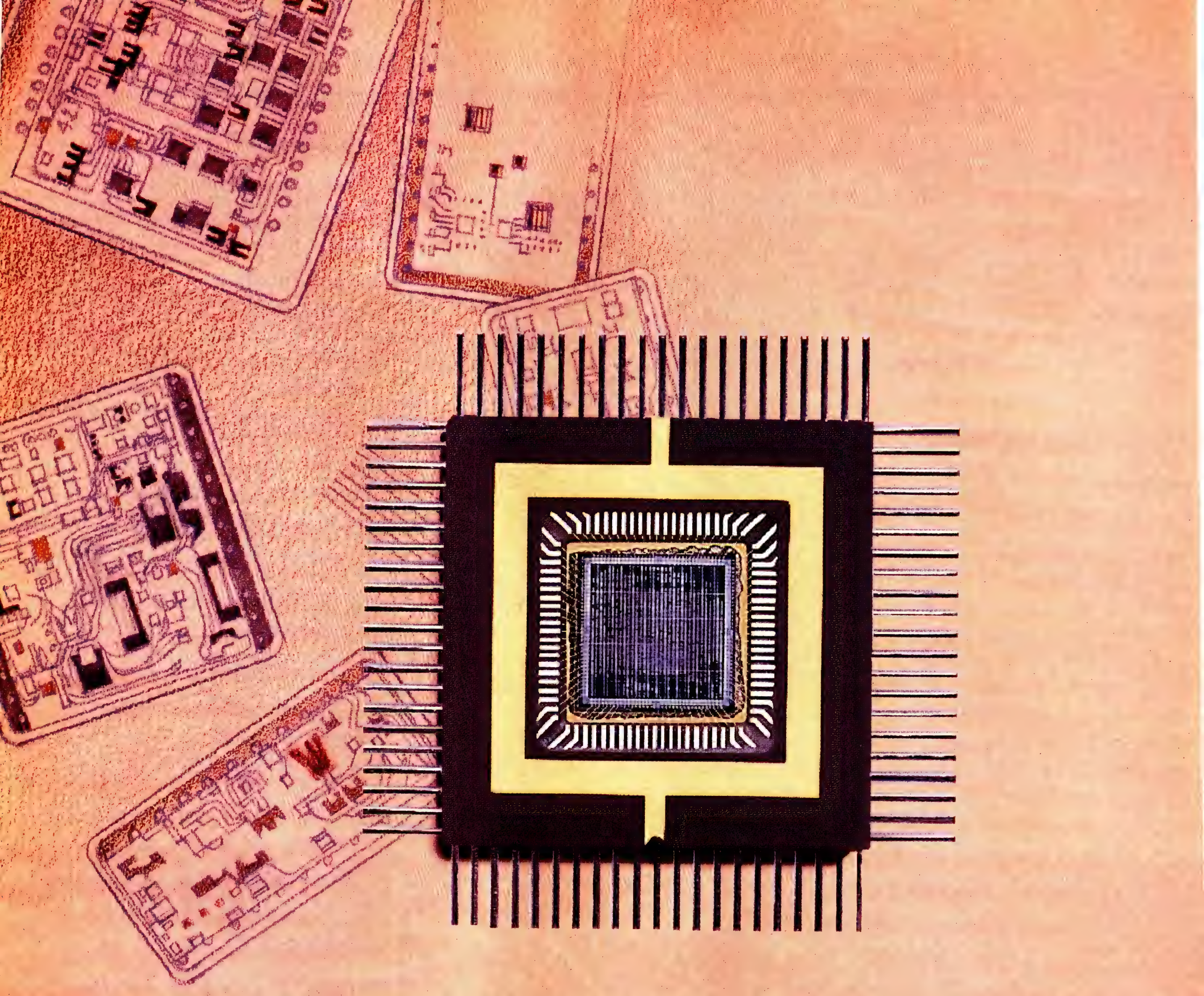

A compact 1553 that carries a busload

The UT1553B BCRT data bus system proves that big things do come in small packages. It's loaded with features including both MIL-STD-1553B Bus Controller and Remote Terminal functions and advanced, specialized memory management—all on one low-power CMOS chip.

It's the next generation product in our 1553 family. The BCRT was designed to reduce host intervention with automatic DMA and address generation. It automatically executes message transfers, provides interrupts, and generates status information. UTMC's BCRT allows you to implement a pseudo-transparent dual-port RAM configuration.

The BCRT's bus controller uses a linked-list message scheme to provide the host with message "chaining." Memory space is optimized by using programmable address pointers. As an RT, the BCRT implements time tagging and message history functions. It also supports multiple-message buffering—up to 128—including variable-length messages to any subaddress.

The BCRT complies with the standard LAN used for military systems while meeting selected tests in MIL-STD-883C. It is available in 84-pin LCCs, PGAs, or Cerquads.

Don't miss the bus on your 1553 system needs. Call UTMC.

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1575 Garden of the Gods Road
Colorado Springs, Colorado 80907
1-800-MIL-UTMC

UNITED TECHNOLOGIES MICROELECTRONICS CENTER

CIRCLE NO 177

pacitance; you can use the equations to scale one experiment into many designs. $399.

Piezo Electric Products Inc, 186 Massachusetts Ave, Cambridge, MA 02139. Phone (617) 547-1777.

Circle No 368

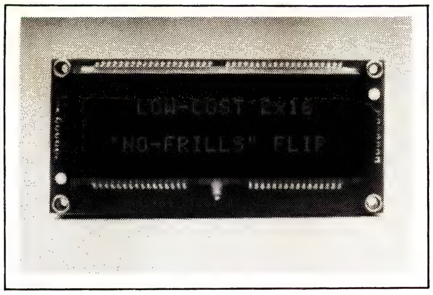
DISPLAY MODULE

- *Single-supply operation*
- *Designed for OEM applications*

The Model 3601-87-032 5×7 dot-matrix, 2-line×16-character vacuum-fluorescent display module is designed for OEM applications. An onboard µP controller handles all scan, refresh, and data I/O tasks, easing the interface with an 8-bit parallel data bus. Only 5V dc power is required for operation. The modules display the full 96-character ASCII font of upper and lower case letters, numbers, and symbols. The display characters are blue-green, but a variety of color filters is available to fit almost any application. $87 (100). Delivery, four to six weeks ARO.

IEE Inc, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 367



TRIACS

- *Rated for 6 or 8A rms, 200 to 600V*
- *Have specified commutation conditions*

The BTA06 and BTA08 triacs specify the necessary $(dI/dt)_c$ and $(dV/dt)_c$ conditions during commutation, so you can determine the maximum current that the triacs can control without the risk of spurious firing. With this information, you can better predict the triacs' performance when you make a tradeoff between sensitivity and switching capability. The BTA06 is a 6A rms triac with an I_{GT} rating of 5 mA; the BTA08 is an 8A rms triac with an I_{GT} rating of 10 mA. Both devices are available with voltage ratings of between 200 and 600V. BTA06, $0.56; BTA08, $0.80 (1000).

Thomson Semiconducteurs, 45 Ave de l'Europe, 78140 Velizy, France. Phone (1) 39469719. TLX 204780.

Circle No 365

Thomson Components-Mostek Corp, 1310 Electronics Dr, Carrollton, TX 75006. Phone (214) 466-6000. TLX 730643.

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Economy Card

The HK68/VE is an economically-priced VME convertible with plug-in modules that allow for easy customization. This 16-bit board is versatile enough to handle rough "real-time" road conditions, as in data acquisition or control. Standard equipment includes:

▪ Motorola 68010 CPU ▪ Up to 1MB of on-board DRAM with parity ▪ Up to 256K EPROM ▪ 16-bit iSBX connector ▪ 2 Serial Ports ▪ Mailbox interrupt support

Options include 4-channel DMAC, 68881 Floating Point Processor module and SCSI interface module.

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Take Heurikon's HK68/VE for a spin today. Call toll-free: 1-800-356-9602 (ext. 406).

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CIRCLE NO 32

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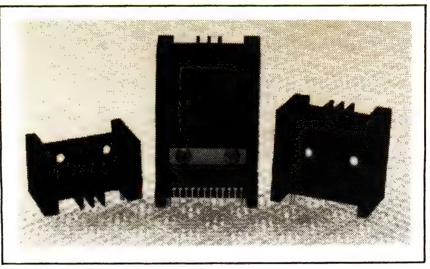


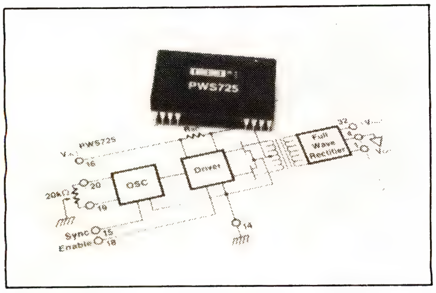
HEAT SINKS

- *Designed to cool SIPs and ZIPs*
- *6.5°C/W thermal resistance*

The Series 6380 heat sinks are designed specifically to cool ICs housed in a single in-line package (SIP) or a zigzag in-line package (ZIP). They dissipate heat in the 10 to 15W range and feature standard solderable roll pins. Roll pins with standoffs are available as an option. At a 75°C mounting-surface temperature rise, the thermal resistance is 10°C/W for the 1-in. 6380B, 7.9°C/W for the 1.5-in. 6381B, and 6.5°C/W for the 2-in. 6382B. The devices are screw mounted through two holes on 0.78-in. centers in the device tab. The heat sinks are also available with optional self-clinching fasteners or threaded studs for easy assembly. $0.56 (1000) for the 6380B.

Thermalloy Inc, Box 810839, Dallas, TX 75381. Phone (214) 243-4321.

Circle No 369



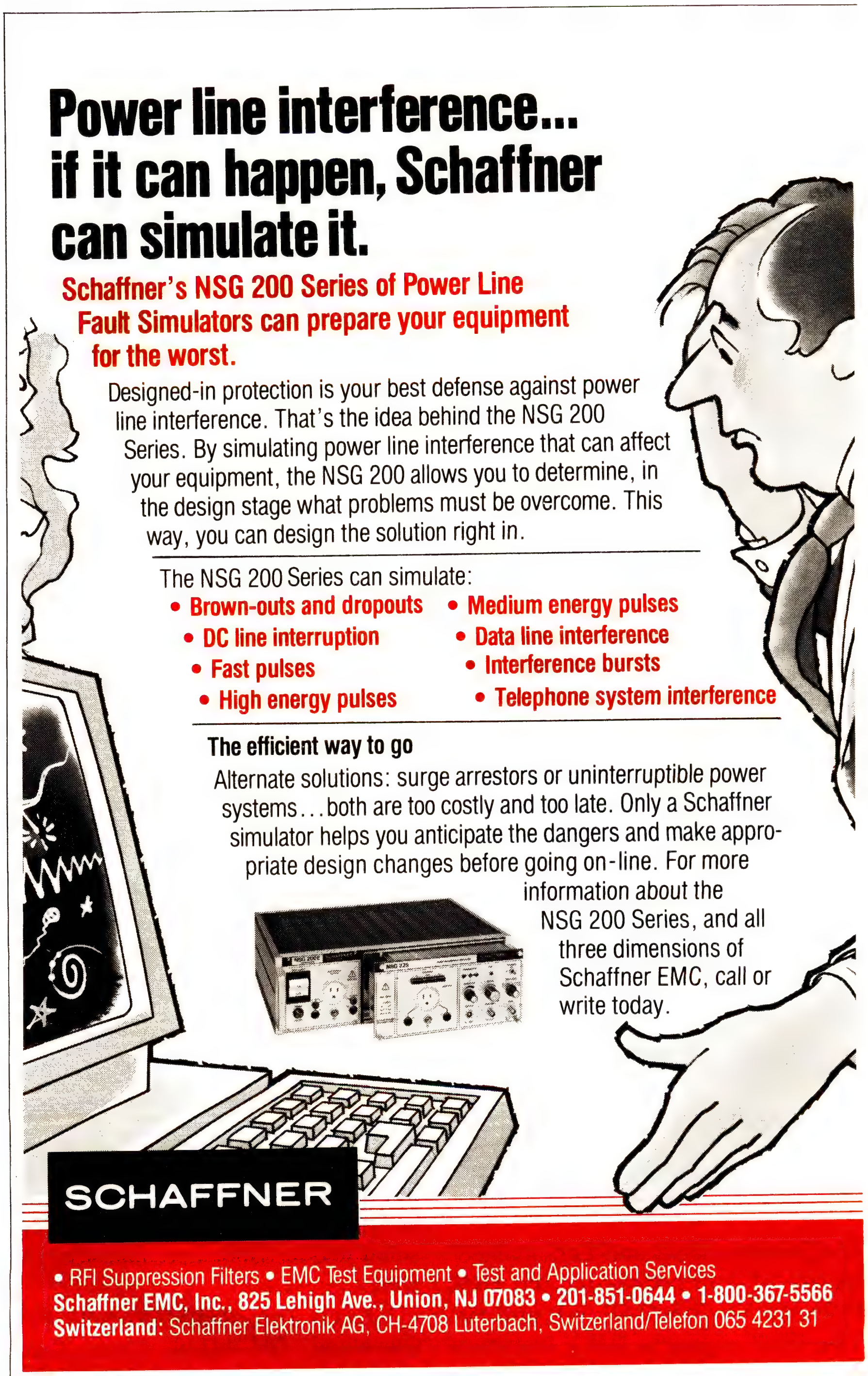
DC/DC CONVERTER

- *1500V input/output isolation*
- *Design eliminates high inrush currents during turn-on*

The PWS725 converter supplies ±7 to ±18V dc outputs at ±40 mA. The galvanic input-to-output isolation (100% tested at 4000V dc) is guaranteed at 1500V rms. The converter specs a 1.2-μA leakage current (at 240V ac, 50/60 Hz) and a 9-pF leakage capacitance. The converter includes an oscillator, a driver circuit, dc switches, a transformer, internal filter capacitors, and a rectifier. A soft-start oscillator design ensures full operation of the oscillator before either MOSFET driver turns on, protects the switches, and eliminates high inrush currents during turn-on. Input current sensing protects both the converter and the load from possible thermal damage. $21.30 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

Circle No 370


Power line interference... if it can happen, Schaffner can simulate it.

Schaffner's NSG 200 Series of Power Line Fault Simulators can prepare your equipment for the worst.

Designed-in protection is your best defense against power line interference. That's the idea behind the NSG 200 Series. By simulating power line interference that can affect your equipment, the NSG 200 allows you to determine, in the design stage what problems must be overcome. This way, you can design the solution right in.

The NSG 200 Series can simulate:

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- **Medium energy pulses**
- **Data line interference**
- **Interference bursts**
- **Telephone system interference**

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Alternate solutions: surge arrestors or uninterruptible power systems...both are too costly and too late. Only a Schaffner simulator helps you anticipate the dangers and make appropriate design changes before going on-line. For more information about the NSG 200 Series, and all three dimensions of Schaffner EMC, call or write today.

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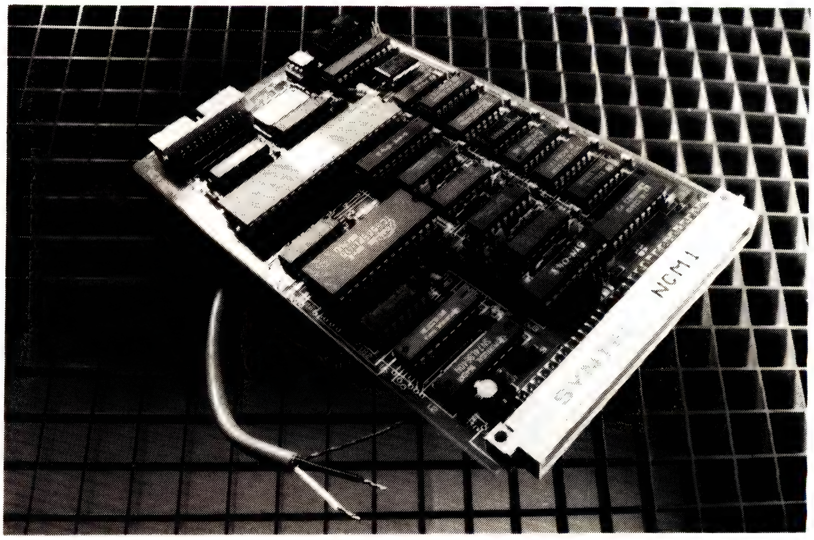
CIRCLE NO 33

LAN

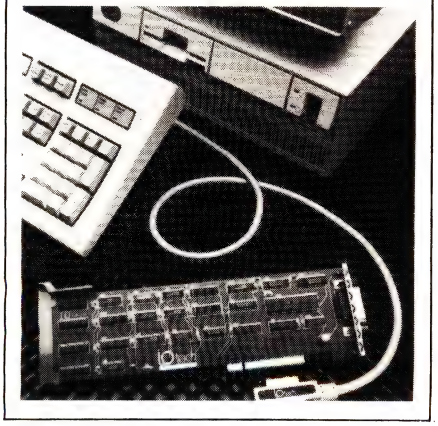
- *Provides low-cost networking*
- *Has an interface card for the G64 bus*



Sycom is a local-area network for use in industrial control applications. It uses low-cost twisted-pair cabling, a multidrop network topology, and a token-passing protocol. Transmissions over the LAN use Manchester-encoded, 1M-bps, RS-422-level data transfers. You can connect as many as 256 nodes to the network by using simple T-connectors. The company's current interface offering is a single-Eurocard G64 bus board, which provides a token-bus controller chip, Manchester encoder, and RS-422 LAN driver. It also has an interface for a user's modem or an alternative transmission medium. Software support for the board includes a driver for message delivery over the LAN and an OS-9 network file structure. Interface cards for VME Bus systems and IBM PCs are planned. The G64 bus LAN interface card costs £398.

Syntel Microsystems, Queens Mill Rd, Huddersfield HD1 3PG, UK. Phone (0484) 535101.

Circle No 398



IEEE INTERFACES

- *Compatible with DOS-based languages*
- *Provide vectoring on service requests*

The Personal488/2 and Personal488/2A are plug-in boards for the IBM Personal System/2-50, 60, and 80. The 488/2 supports DMA transfers to 330k bytes/sec, and the 488/2A can execute DMA transfers as fast as 1M bytes/sec. The boards are compatible with all DOS-based languages and remain part of the DOS once installed—that is, they don't need to be loaded each time you use the system. The boards feature built-in error checking that allows them to stop a program and notify you when a syntax error or a bus time out occurs. They offer full IEEE control for as many as 14 bus devices. The boards also provide vectoring on service requests, allowing a Basic program to act on these conditions without polling routines. They have seven software-selectable interrupt levels, 15 selectable DMA arbitration levels, and 256 selectable base addresses, and no DIP switches or jumpers. Personal 488/2, $495; Personal 488/2A, $595.

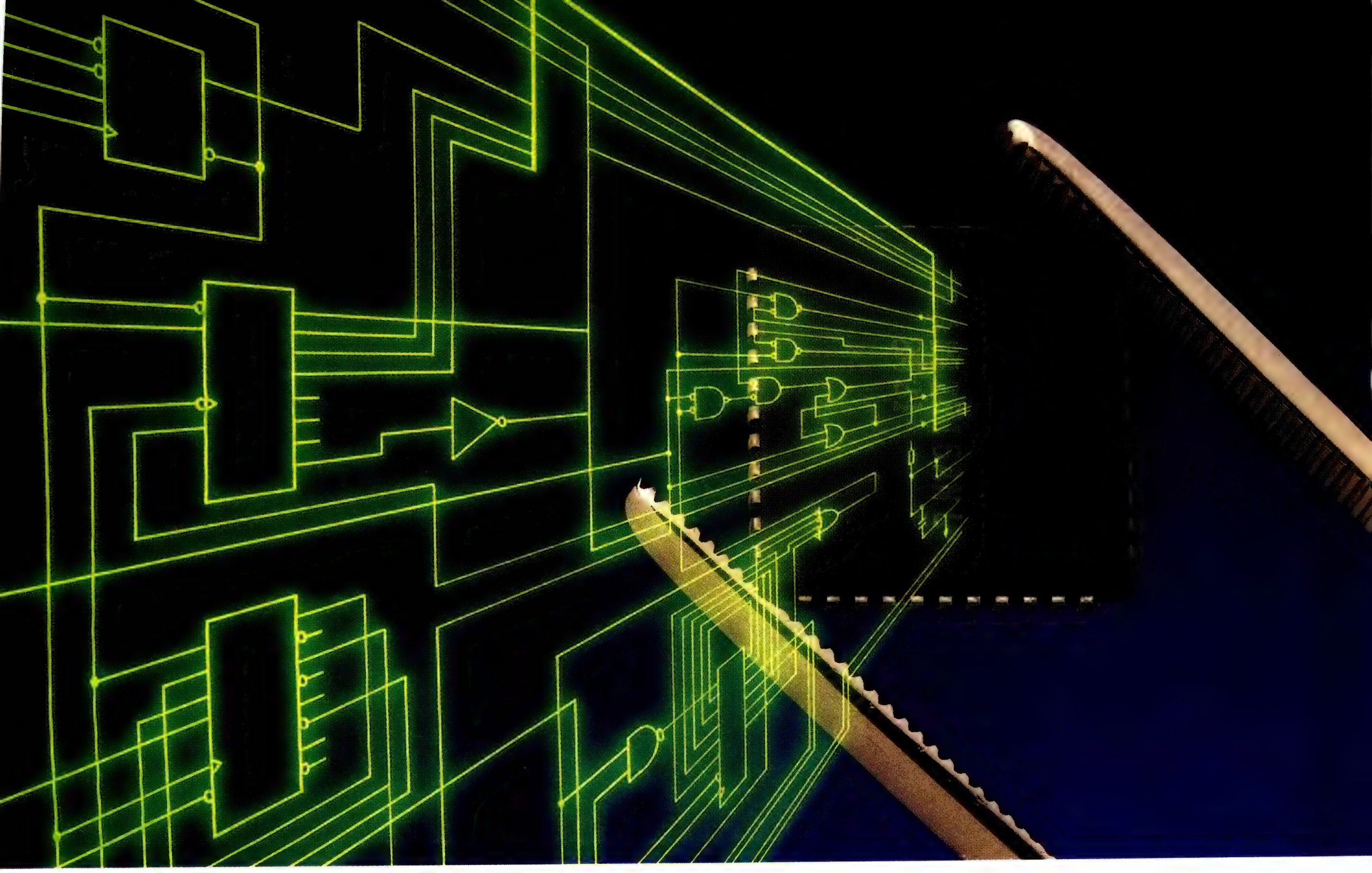
IOtech Inc, 23400 Aurora Rd, Cleveland, OH 44146. Phone (216) 439-4091.

Circle No 399

PRINTER

- *24-pin printer prints at 450 cps in draft mode*
- *Bit-image graphics with resolution to 360×360 dots/in.*

The Microline 393 is a 24-pin printer that offers four print speeds: 450 cps in a high-speed draft mode; 360 cps in a utility mode; 180 cps in a near-letter-quality mode; and 120 cps in a letter-quality mode. Front-panel buttons select print speed, pitch (cpi), and font. It offers a "paper park" feature that lets you insert a single cut sheet without removing



THE FIRST PROGRAMMER WITH A SINGLE SITE FOR EVERY DEVICE.

NEW UNISITE 40 HANDLES LEADING-EDGE DEVICES WITH SPEED AND EASE. Now you can program and test the latest programmable devices and packages, fast and accurately — all in a single site. The first true universal pin drivers support any device of a given package type in the same site. The UniSite™ 40's single DIP socket handles any device up to 40 pins, including PLDs, PROMs, IFLs, FPLAs, EPROMs, EEPROMs, and microcontrollers. The same site accommodates the most popular PLCCs and SO packages. A 16-bit processor, coupled with custom ICs and high-speed RAM, set new speed records for programming and testing.

TIMELY ACCESS TO TOMORROW'S DEVICES. With universal pin driver electronics hardware, device-specific instructions can be loaded from one 3½″ micro-diskette. When new devices are introduced, you simply load a new master diskette, and the UniSite 40 is quickly updated.

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(03) 432-6991/Telex 2522685 DATAIO J

DATA I/O

CIRCLE NO 178

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the continuous form paper loaded in the printer. The maximum noise rating is 57 dBa with a special quiet mode of 54 dBa. A hinged tear bar allows you to remove printed material without wasting or repositioning the paper. It has a Centronics parallel port and an RS-232C interface. When interfaced to a computer, a software module emulates the Epson LQ series of printers. You can print bit-image graphics at resolutions to 360×360 dots/in. The printer comes in two models, black-only and color. Black-only model, $1399; color printer, $1499.

Okidata, 532 Fellowship Rd, Mount Laurel, NJ 08054. Phone (609) 235-2600. TWX 710-897-0792.

Circle No 400

Widest selection of modular enclosures

Collet safety knobs

- Firmer grip on shaft
- Mix or match colors

Fully VME compatible!

- Completely insulated
- Free positioning

- Portable instrument cases from 3.5″ to 10.5″ height, 8.4″ to 16.8″ width and 10.2″ to 19.9″ depth
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For further information just call (415) 656-3400

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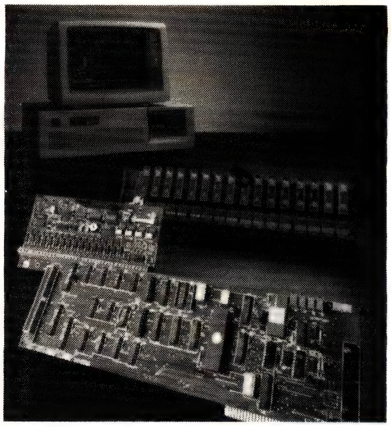


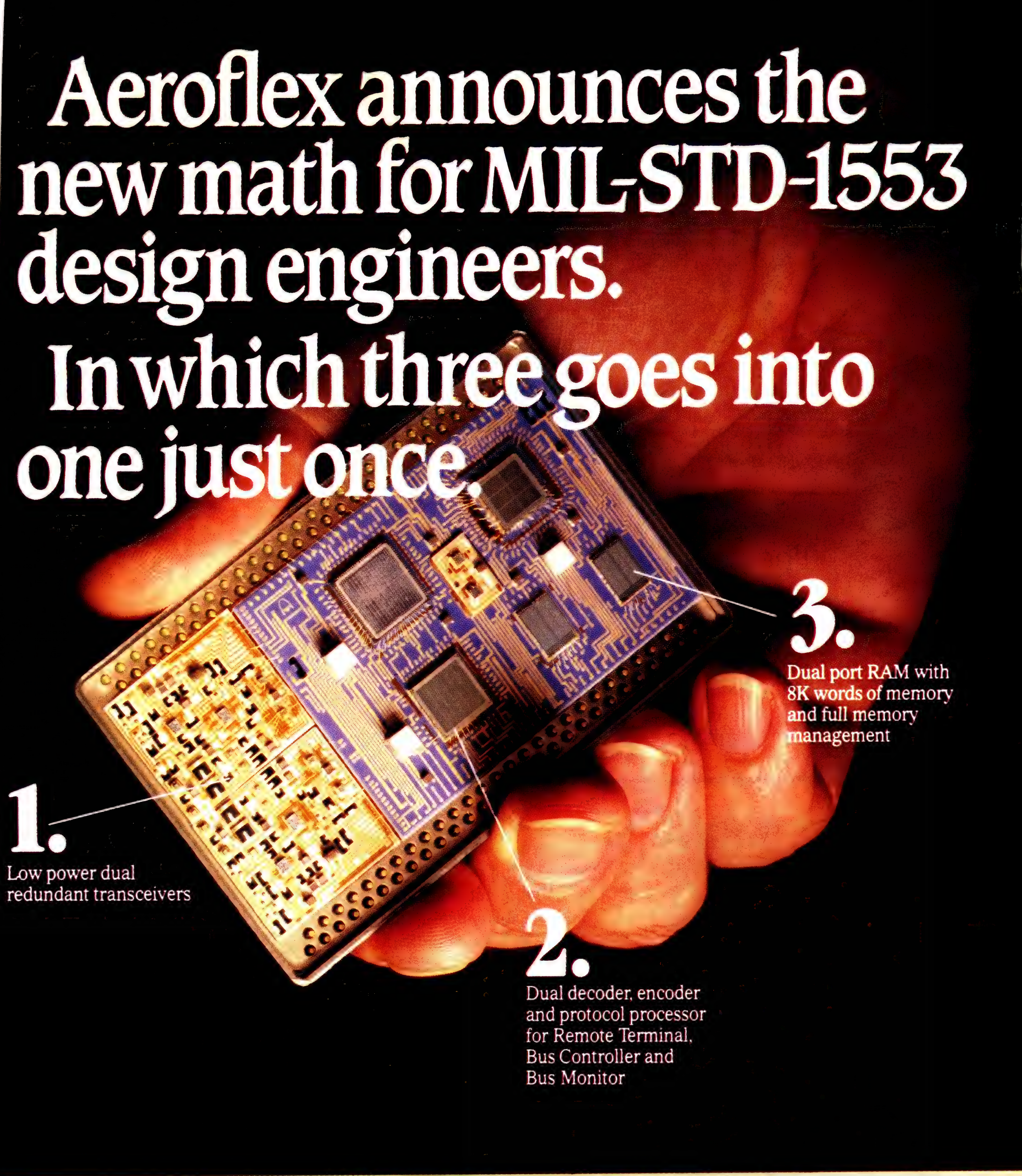
I/O BOARD

- *Can handle 64 analog inputs and 16 analog outputs*
- *Data-acquisition rates as high as 19 kHz for the IBM PC*

The RTI-820 is an analog and digital I/O board that plugs into the IBM PC, PC/XT, and PC/AT. The digital portion has three 8-bit digital I/O ports that are compatible with solid-state-relay subsystems and the company's digital panels. The analog section contains a 12-bit A/D converter and a 12-bit D/A converter, which provide one channel of analog input and one channel of analog output, respectively. Multiple channels are connected to the interface panels by multiplexing several inputs and outputs to their respective channels. For nonisolated analog I/O applications, an external panel provides 16 high-level (0-10V) single-ended analog inputs and four analog outputs. Four panels can have 64 analog inputs and 16 analog outputs with data-acquisition rates as high as 19 kHz. A signal-conditioning panel accommodates as many as 16 modules for isolated signal conditioning. The modules feature ±1500V rms isolation, 160 dB common-mode rejection, and ±240V rms protection. RTI-820, $600; high-level panel, $350; isolation panel, $260.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 461-3565. TWX 617-461-3565.

Circle No 401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Low power dual redundant transceivers

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3.
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You are looking at the most powerful, flexible and unique MIL-STD-1553B interface currently available. Bar none.

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For additional information call toll-free: 1-800-THE-1553 or TWX 510-224-6417. Or write
Aeroflex Laboratories Inc.,
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Plainview, NY 11803.

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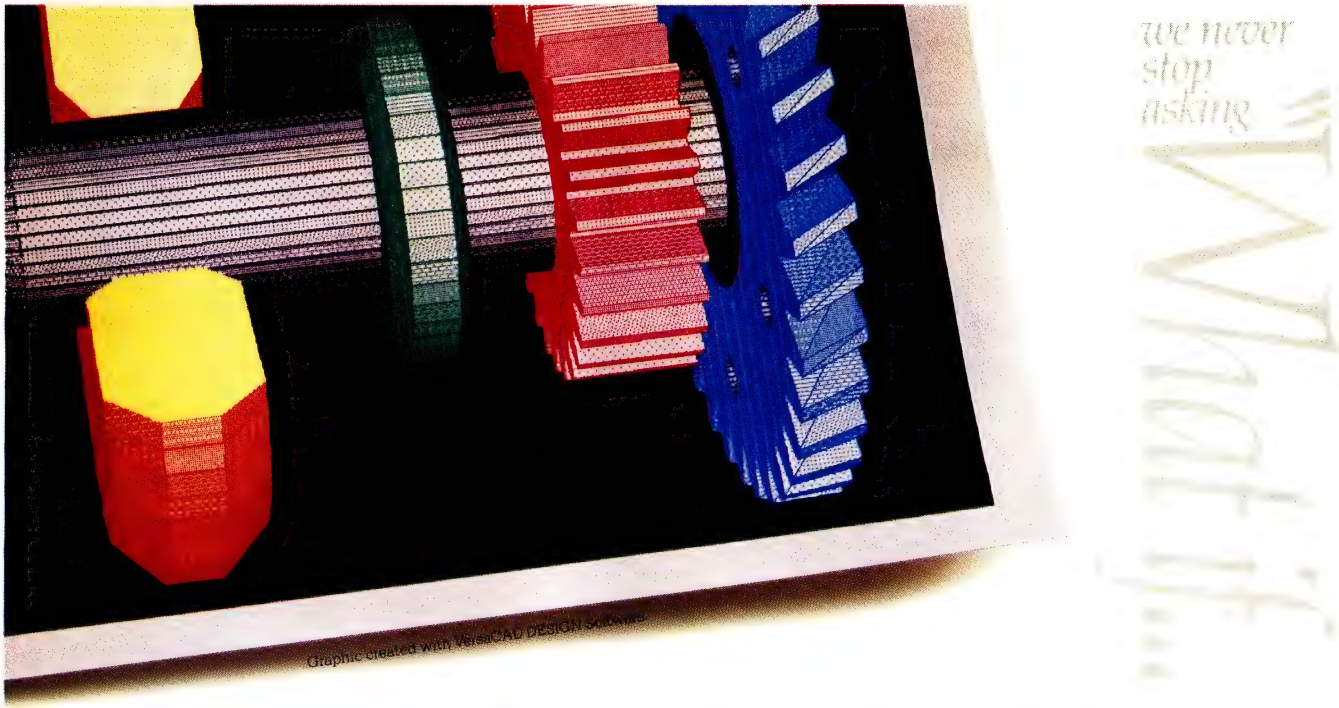
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The new HP PaintJet color graphics printer.
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COMPUTERS & PERIPHERALS

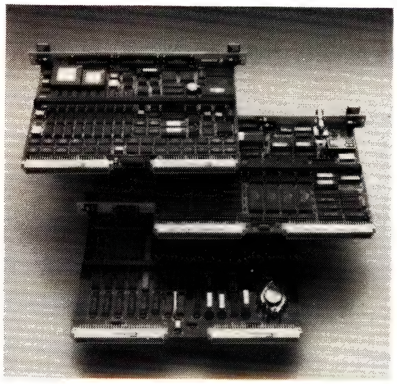
MONOCHROME MONITOR

- *Delivers 1600×1280-pixel resolution*
- *Display controller occupies one Macintosh II slot*

The Vista 1600 is a 19-in. monochrome monitor with 1600×1280-pixel resolution. It includes a display generator controller card that occupies one expansion slot in the Macintosh II. It also runs with the IBM PC, PC/XT, PC/AT, and compatibles, as well as 80386-based systems. When combined with the 32-bit processing power of the Macintosh II, the monitor is suitable for such high-performance applications as CAE/CAD/CAM, medical imaging, and CASE. Its applications for IBM PC computers include desktop publishing, CAD, and programming-intensive applications such as expert-system development. The card occupies one slot in the PC and emulates the IBM CGA graphics standard. It has a noninterlaced screen that is refreshed at a 67-Hz rate and has a video bandwidth of 200 MHz. It is compatible with Microsoft Windows, AutoCAD, Lotus 1-2-3, and Ventura Publisher. IBM version, $2395; Macintosh II version, $2195.

Cornerstone Technology, 175A E Tasman Dr, San Jose, CA 95134. Phone (408) 433-1600. TWX 910-250-0853.

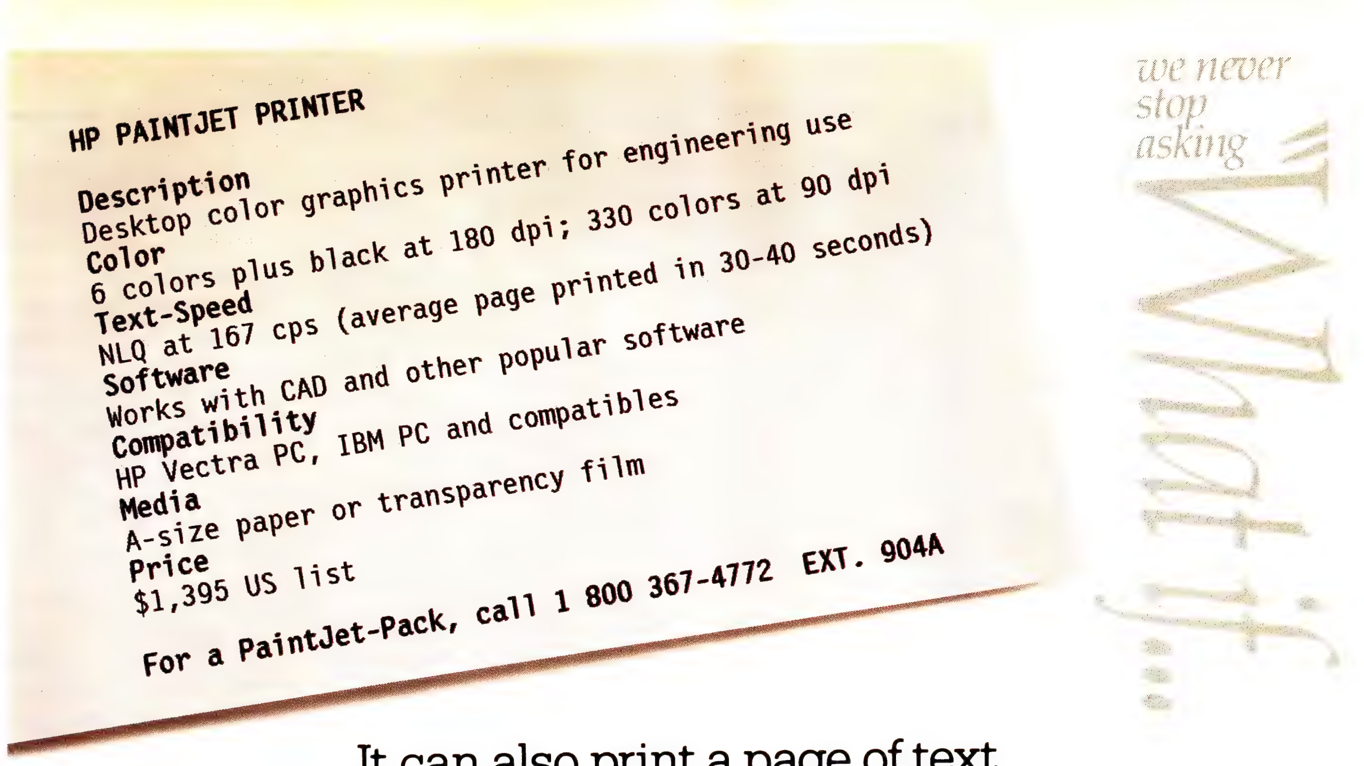
Circle No 402



BOARD SET

- *VME Bus board set runs on converged Unix*
- *Implements a Sun-3 workstation in a flexible package*

The Sun-3 Eurocard is a VME Bus board set that runs on the company's converged Unix operating system. Three boards can implement a complete Sun-3 workstation. The board set consists of a CPU board with a 20-MHz 68020 μP, 4M bytes



HP PAINTJET PRINTER

Description
Desktop color graphics printer for engineering use
Color
6 colors plus black at 180 dpi; 330 colors at 90 dpi
Text-Speed
NLQ at 167 cps (average page printed in 30-40 seconds)
Software
Works with CAD and other popular software
Compatibility
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It can also print a page of text
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CIRCLE NO 35

of main memory, and the converged Unix operating system; a monochrome video frame-buffer interface board; and SCSI and Ethernet boards. Each double-height Eurocard board measures 233×160 mm. The boards are suitable for rugged applications. Because of their size and modularity, they are useful in embedded systems. CPU board, $7700; Ethernet/SCSI board, $2300; video board, $1800.

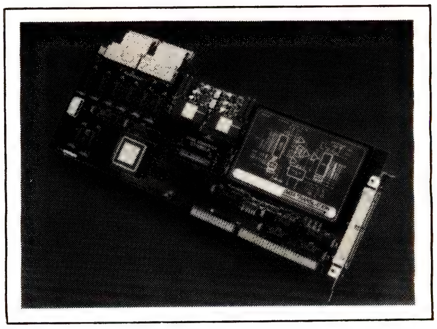
Sun Microsystems Inc, 2550 Garcia Systems, Mountain View, CA 94043. Phone (415) 691-6424.
Circle No 403

VOICE RECOGNITION

- *Has 400-word-recognition vocabulary*
- *Provides unlimited text-to-speech synthesis*

The IntroVoice VI is an add-in board for the IBM PC/XT, PC/AT, and compatibles that combines a voice recognition of 400 words with an unlimited text-to-speech synthesis. It accomplishes speech recognition by measuring and comparing the sound energy in a 16-channel audio-spectrum analyzer over a 48-dB dynamic range. The board allows for as many as 1000 characters per spoken word; the duration of each spoken word can be 0.08 to 1.25 sec. To operate in the recognition mode, the board uses PC-DOS, MS-DOS, or Basic. If a spoken utterance is different from the training samples, a routine looks for the closest match. The unit has a programmable rejection threshold that provides a built-in safeguard to protect against false recognition. When the board recognizes a word, it sends an associated keystroke sequence (of as many as 1000 keystrokes per word) to the computer, as a keyboard does. The board requires 100k bytes of memory for I/O software. The IntroVoice VI, with a handheld microphone, costs $595.

The Voice Connection, 17835 Skypark Circle, Suite C, Irvine, CA 92714. Phone (714) 261-2366.
Circle No 404



I/O BOARDS

- *750-kHz data acquisition on the IBM PC/AT*
- *Transfers data over an external port to the processor board*

The DT2841 Series is a set of analog and digital I/O boards for the IBM

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High-Accuracy
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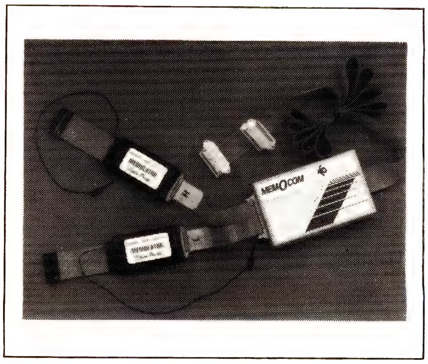
CIRCLE NO 36

PC/AT. The series provides 12- or 16-bit A/D inputs and two 12-bit D/A outputs. The boards use an external I/O port (called DT-Connect) to transfer data to a processor board (such as the company's DT7020 array processor); this method avoids the slower IBM PC/AT bus. The models differ in their analog input characteristics and throughput speeds. Inputs can be two sets of 4 SE (single-ended), 4 DI (differential-input), 8 DI, or 16 SE, depending on the model. A/D throughputs can range from 40 kHz to 750 kHz. The two D/A channels can provide either single or dual simultaneous outputs at rates as high as 130 kHz/channel. In addition, each board contains 16 lines of digital I/O organized as two 8-line ports. Each port can be programmed for input or output transfers. Two pacer clocks allow input and output operations to occur simultaneously at the same or different rates. Prices range from $1450 to $2995, depending on the model.

Data Translation Inc, 100 Locke Dr, Marlboro, MA 01752. Phone (617) 481-3700. TLX 951646.

Circle No 405



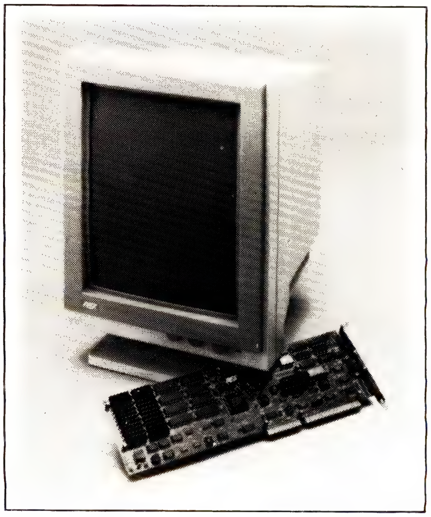
EPROM EMULATOR

- *Emulates two 28-pin or 24-pin JEDEC EPROMs*
- *Downloads assembler or compiler code into EPROM sockets*

The Memulator 16 is a dual in-circuit EPROM emulator that simultaneously emulates two 28-pin or 24-pin JEDEC EPROMs (2716 thru 27256). It allows you to download assembler or compiler code directly into the EPROM sockets at rates as fast as 64k bytes in 18 sec. Access times of 50, 100, or 150 nsec are available. The target processor recognizes the emulator code as two EPROMS in the sockets. A monitor command set in the firmware allows you to load, examine, modify, and patch program code into the emulation memory image from a PC, terminal, VAX, or any host development system with at least one RS-232C port at rates as high as 38.4k baud. The target processor can write to the emulator, giving you added debugging capability. The emulator accepts Intel hex, Motorola S-record, and straight binary formats. It draws power from each target socket at approximately 35 mA from 5V. $975.

Memocom, 1920 Arbor Creek Dr, Carrollton, TX 75010. Phone (214) 446-9906.

Circle No 406



DESKTOP SUBSYSTEM

- *Draws an 8.5×11-in. page of text and graphics on screen*
- *Subsystem works with the IBM PC/XT and PC/AT*

The TurboVision is a graphics board and monitor for the IBM PC/XT, PC/AT, and compatible computers. Designed for desktop publishing applications, the subsystem features WYSIWYG (what you see is what

IS SCOPE SETUP A SOURCE OF DELAY?

The Tek 2465A with AUTO SETUP is the time-saving solution. See up to four waveforms on-screen at the touch of a button. Your display is triggered and scaled automatically, without having to adjust a single knob. Add other standard features such as 350 MHz probe-tip bandwidth, 2 mV/div sensitivity and auto trigger level—all in a scope made for solving tough problems in analog design. It makes troubleshooting trouble-free!

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- ☐ Please send me your free videotape introduction, "The 2445A/2465A Family: From Performance to Productivity."
- ☐ Please send me your free 22-page brochure.
- ☐ Please have a Tek representative get in touch with me as soon as possible to arrange a demonstration.

D887-6-38AX EDN

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Accurate measurements, accurately interpreted. The 350 MHz 2465A builds on proven, industry-standard high performance. You can easily measure pulse parameters and frequency with on-screen cursors. Full bandwidth is maintained at 2 mV/div sensitivity to monitor low-amplitude signals such as noise and ripple with full fidelity.

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Measurement options, extended capabilities. For specialized performance requirements, five combinable enhancements are available—a GPIB interface, digital multimeter, counter/timer functions with enhanced triggering, 17-bit word recognition and video measurement capabilities.

Three multiple-option packages, the 2465A Special Editions, are configured for specific application areas at a significant savings over the separately ordered options.

All models come with Tek's comprehensive three-year warranty on labor and parts, including the CRT.

Key Features	2465A DV	2465A DM	2465A CT	2465A	2445A
Probe Tip Bandwidth	350 MHz	350 MHz	350 MHz	350 MHz	150 MHz
No. of Channels	4	4	4	4	4
Horizontal Accuracy	2% (.001%*)	2% (.001%*)	2% (.001%*)	2% (.001%*)	2% (.001%*)
Max. Sweep Speed	500 psec	500 psec	500 psec	500 psec	1 nsec
Vertical Sensitivity	2 mV/div	2 mV/div	2 mV/div	2 mV/div	2 mV/div
Trigger Frequency	500 MHz	500 MHz	500 MHz	500 MHz	250 MHz
GPIB	Standard	Standard	Standard	Optional	Optional
Counter/Timer/ Trigger/Word Recognizer	Standard	Standard	Standard	Optional	Optional
Digital Multimeter	Standard	Standard	Not Available	Optional	Optional
Video Trigger	Standard	Not Available	Not Available	Optional	Optional
Probes	4	4	4	2	2
Warranty	3 years on parts and labor, including CRT				

*with Counter/Timer/Trigger

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you get) graphics. Using this subsystem, you can quickly draw a full 8.5×11-in. page of text and graphics on the monitor's screen exactly as it will appear when printed out with a laser printer. The product includes a 1024×1280-pixel monochrome monitor, and the board incorporates a TI 34010 graphics engine. The monitor has a 107-MHz bandwidth with a 79.6-kHz scan rate, as well as a 60-Hz noninterlaced refresh rate. The monitor's paper-white, phosphor flat screen is designed to simulate a printed page. The subsystem supports a variety of fonts—including Courier, Symbol, Letter Gothic, Swiss, and Dutch—each of which comes in 13 sizes. The system includes software drivers for Microsoft Windows, Lotus 1-2-3, Ventura Publisher, and Pagemaker. $1995.

AST Research Inc, 2121 Alton Ave, Irvine, CA 92714. Phone (714) 863-1333.

Circle No 407

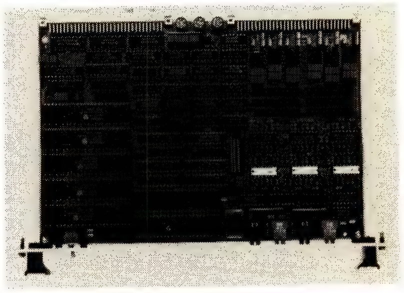
PRINTER NETWORK

- *Four IBM PCs can share two parallel printers*
- *Stores 200 to 300 pages of data in 512k-byte buffer*

The PrintNet II is a printer-network device that increases the distance between printers and PCs to more than 100 ft. It allows as many as four IBM PCs to share a printer buffer and a maximum of two parallel printers. The device receives data from the PCs and stores it in an internal 512k-byte buffer, which typically represents 200 to 300 pages; it simultaneously directs the data to one of the two printers. The device allows you to obtain multiple copies of an entire document or of specific pages. It also lets you instruct the printer to pause automatically after each page so that you can feed in sheets, forms, or labels by hand, and it lets you halt the printer to adjust the paper or change ribbons. The device lets you back up, advance, and reprint pages in the event of paper jams. Its digital displays indicate the number of copies to be printed, the amount of memory used and the amount available, which printer and which computer is in use, and other operating modes. $895 for 512k-byte-storage version.

Support Systems International, 150 S Second St, Richmond, CA 94804. Phone (415) 234-9090. TWX 910-382-8130.

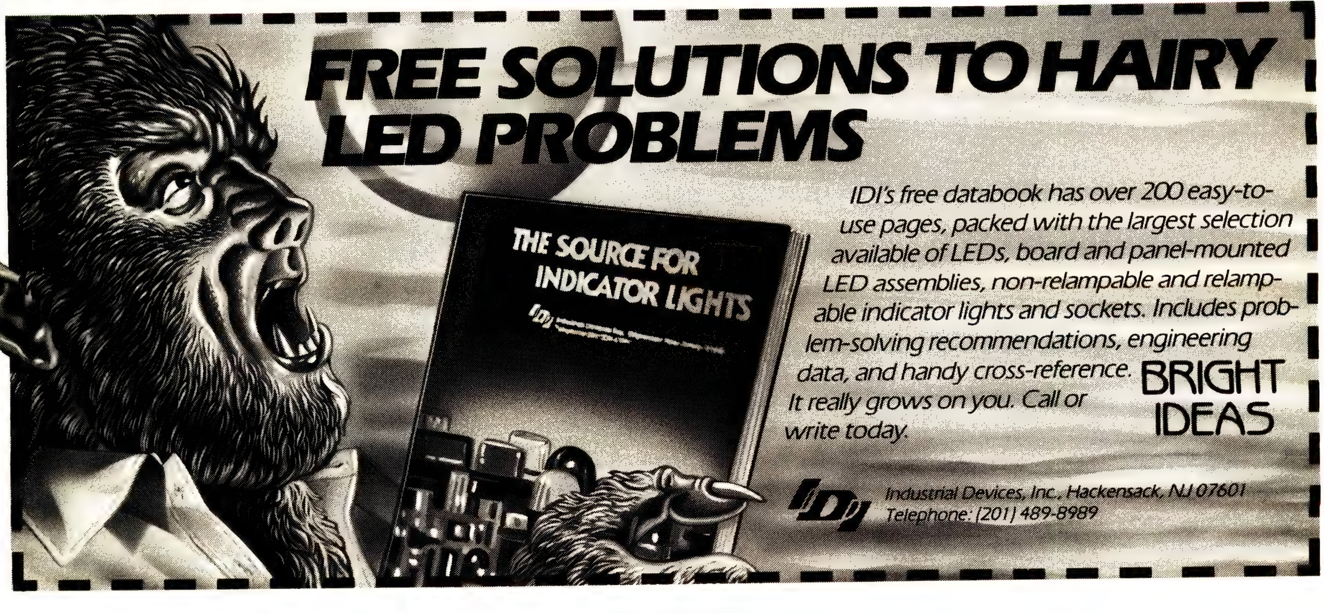
Circle No 408



PROTOCOL BOARD

- *VME Bus board uses 68561 multiprotocol comm chip*
- *Mix of devices to communicate with global gateways*

The SIO-2 offers six independent serial-communication channels on a single VME Bus board. Both the RS-232C and RS-422 device inter-



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Industrial Devices, Inc., Hackensack, NJ 07601
Telephone: (201) 489-8989

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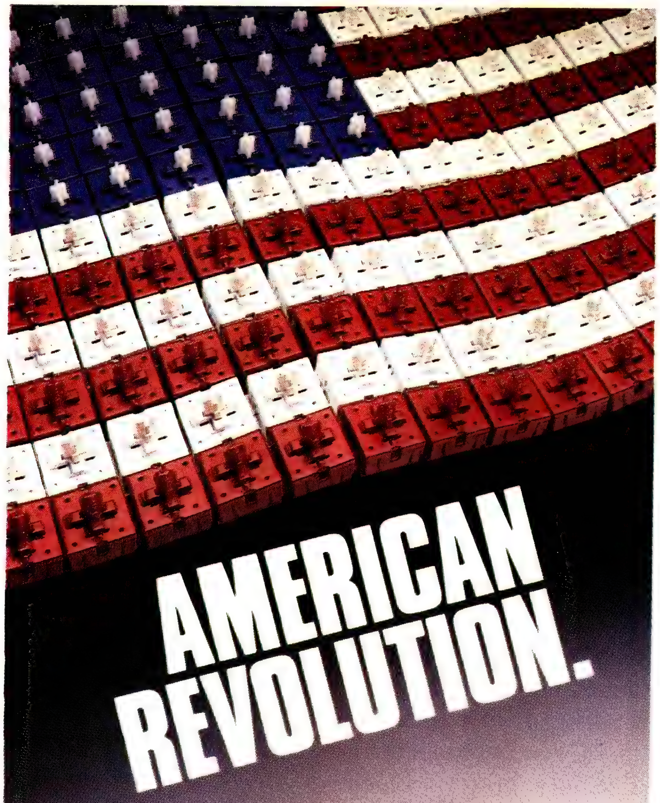


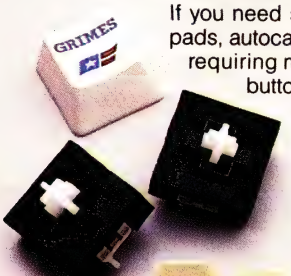
When you're ready to trade your Seoul switch supplier for some Yankee ingenuity, switch to Grimes.

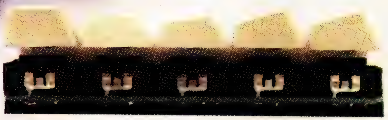
Grimes' low-profile keyboard tactile and non-tactile switches are used by one of the nation's most popular computer manufacturers. Only Grimes makes them with just five parts for greater reliability. And Grimes gives you features like our unique bottom bearing to reduce binding and stamped spiral springs for closer tolerances.

What's more, Grimes' switches cost less because our high-volume automated production reduces assembly costs. And because Grimes is the American switch, it means immediate delivery, no foreign currency hassles and no overseas delivery charges.

If you need switches for keyboards, keypads, autocad digitizers or any application requiring momentary, low-profile pushbutton switches, do yourself a favor. Switch to Grimes.

For a free sample of Grimes' switches, call (714) 671-3931, write to Grimes, or circle the reader service number.





Grimes' switches are compatible with keycaps from Futaba, TeleVideo, LST and other major manufacturers. And our built-in jumper eliminates the need and expense of jumper wires and double-sided circuit boards.

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CIRCLE NO 38

faces are available. It uses the 68561 multiprotocol communications controller chip (MPCC) to run both character- and bit-oriented protocols. Each MPCC enables a software programmable baud rate between 110 and 38.4k baud. They also provide a modem handshake, parity selection, three programmable and maskable interrupt vectors for the receiver, and 22 directly addressable registers. The chip handles both synchronous and asynchronous receiver/transmitter functions and provides operation in full- or half-duplex mode with auto-echo and local loopback. Two optical data-link channels are available. Each channel is fully asynchronous with respect to the VME Bus and can generate an interrupt on any of seven levels. The VME Bus A24 and A16 address decoding and both 8- and 16-bit data are standard. All I/O signals are routed to the VME Bus P2 connector, and each is terminated on board in a 26-pin male connector suitable for flat cable. A separate front panel containing six 25-pin D-subminiature connectors is available as an option. Standard model, $1090.

Force Computers Inc, 727 University Ave, Los Gatos, CA 95030. Phone (408) 354-3410

Circle No 409

Force Computers GmbH, Daimlerstrasse 9, D-8012, Ottobrunn, W Germany. Phone (089) 600-910.

Circle No 410

32-BIT COMPUTERS

- *Can be used in a Xenix or Unix environment*
- *80386 runs at 16 MHz with zero wait states*

The MP 386 Series comprises 80386-based 32-bit personal computers that operate at 16 MHz with zero wait states. The computers' standard features include 32k bytes of cache memory that's expandable to

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CIRCLE NO 196

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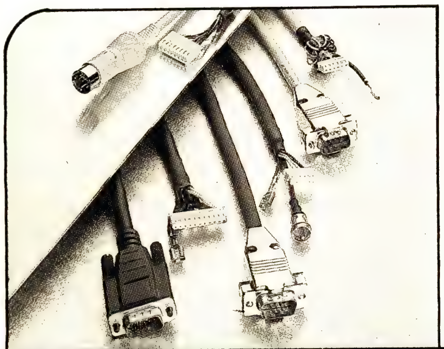

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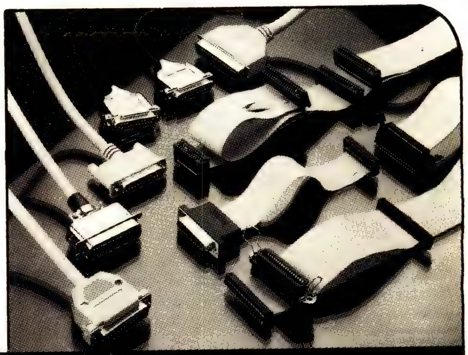

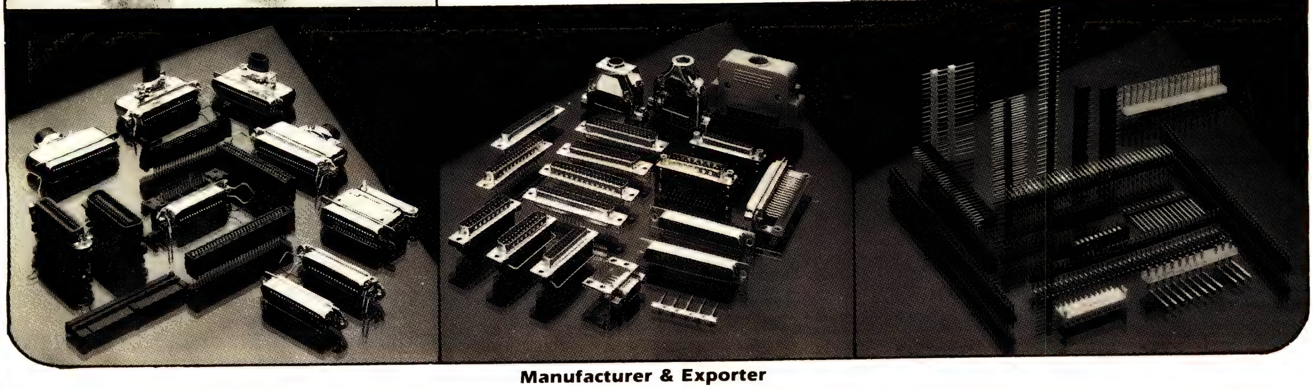

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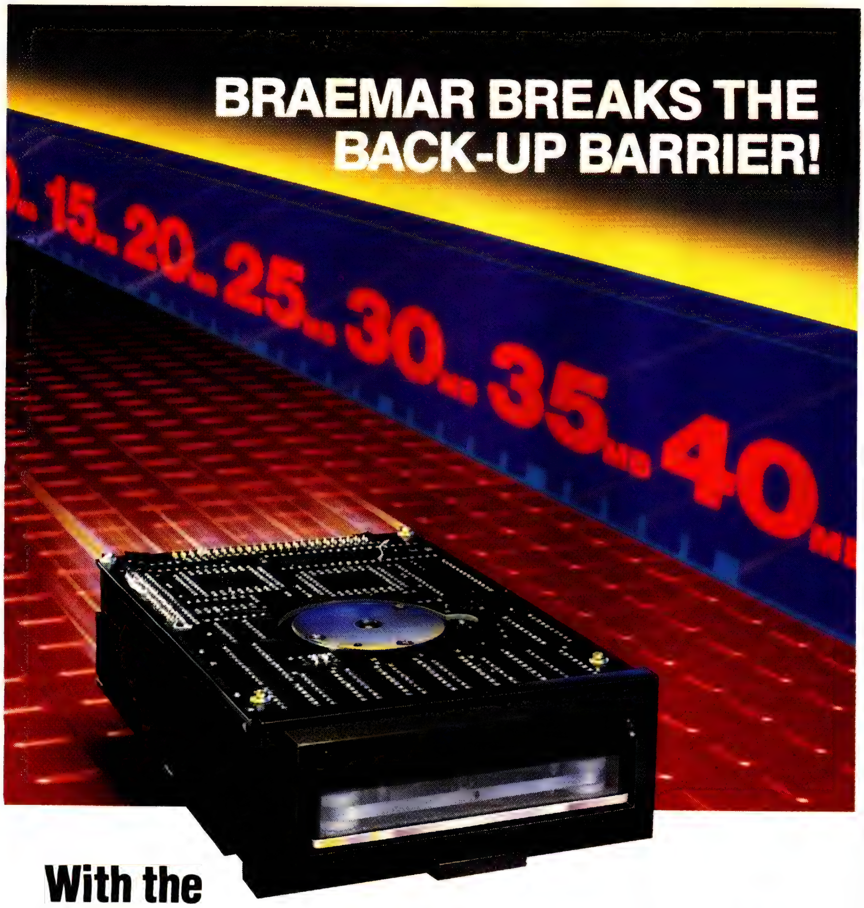
CIRCLE NO 197



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64k bytes, sockets for an 80287 or 80387 coprocessor, 10 expansion slots, and a 5½-in. storage device. The computers run MS-DOS and support most Xenix-based programs. They are available in a number of configurations, including a version having one floppy-disk drive and a version having one floppy-disk drive and a 40M-, 70M-, or 120M-byte hard-disk drive. A 4M-byte expansion-memory board and an intelligent, 8-channel I/O board are optional. 40M-byte configuration, $5995.

Mitsubishi Electronics America Inc, Computer Div, 991 Knox St, Torrance, CA 90502. Phone (213) 515-3993.

Circle No 411

CPU CARD

- *Includes serial, parallel, and SCSI-bus interfaces*
- *Expands via single-Eurocard I/O boards*

The VME-68050 double-Eurocard CPU card is suited for use in VME Bus systems or as a stand-alone computer. It is provided with a 10-MHz 68000 μP, 1M or 2M bytes of zero-wait-state RAM, and sockets for as much as 512k bytes of EPROM. Interfaces include two serial I/O ports, two parallel ports providing 40 TTL-compatible I/O lines, and a SCSI interface. For I/O expansion, the board has an 8-bit Intelligent I/O Channel (IIOC) interface on its P2 connector. A real-time clock/calendar with battery backup is also provided on the board. The VME Bus interface includes a 7-level interrupt handler and a 4-level bus arbiter. The OS-9/68K (V2.0) operating system is available for use with the board. DM 2990 with 1M byte of RAM; DM 3990 with 2M bytes of RAM.

EKF Elektronik Messtechnik GmbH, Weidekampstrasse 1a, 4700 Hamm 1, West Germany. Phone (02381) 12630. TLX 828621.

Circle No 412

Sometimes, one good idea leads to another.

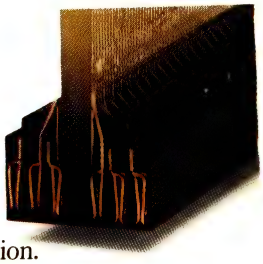
The company that pioneered in-house press fit manufacturing for the backplane and connector industry now offers another unique choice in high density connectors.

A new Six Row High Density Double-Din™ developed by Elfab for backpanel applications is now an Augat connector. With 60 contacts per linear inch, this new connector offers design opportunities unheard of until now.

With traditional design ingenuity, our new surface mount box connector straddles the board, occupying half the real estate of conventional connectors. And providing shorter signal paths for better performance under high speed circuit conditions.

Best of all, conductor path distance is consistent between all six rows, insuring a uniform impedance control between the connector and the printed circuit board.

The same innovation and quality also is available immediately in two and four row connectors, and soon, five and seven row configurations.



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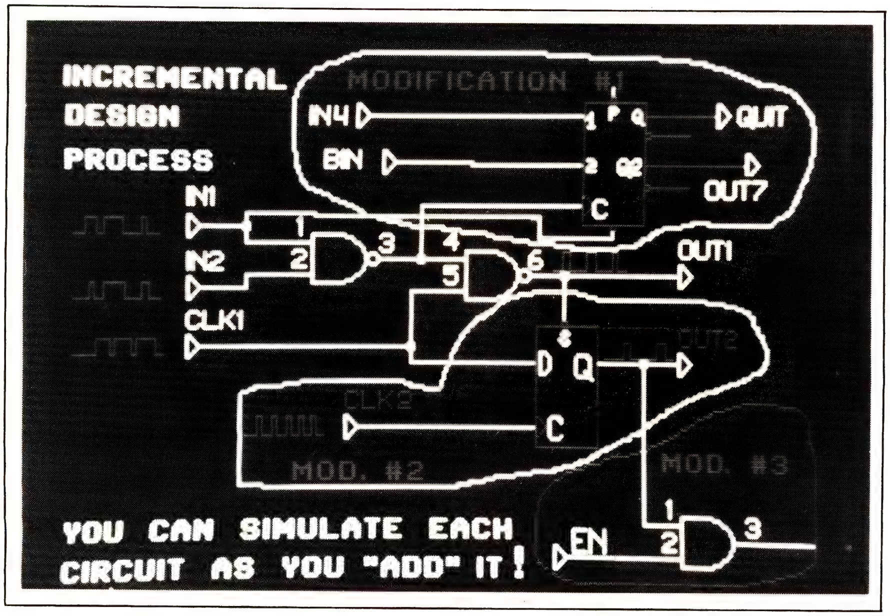
CIRCLE NO 180

CAE & SOFTWARE DEVELOPMENT TOOLS



LOGIC DESIGN TOOL

- *Includes an interactive simulator*
- *Provides interfaces to other CAE software*

Scratchpad combines a schematic-capture editor and an interactive logic simulator. It runs on an IBM PC, PC/XT, PC/AT, or compatible. The package provides libraries of standard TTL- and high-speed CMOS-logic ICs, including one-shots. The program lets you design a complete schematic in step-by-step fashion, and it automatically checks for drafting and design errors. As you complete each section of the design, an incremental compiler compiles the section and a high-speed, interactive simulator verifies it. You can select either a timing display, which shows all the signals (including glitches), or a functional display, which shows only the glitches' functional effects. If the simulator detects no errors, you can convert the section into a module or software macro and store it for use in future designs. The package includes interfaces for transferring any module or complete design to other CAE programs for board layout and other processing. $2950.

Aldec, 3525 Old Conejo Rd, Suite 111, Newbury Park, CA 91320. Phone (805) 499-6867.

Circle No 385

IC DESIGN TOOL

- *Analyzes linear and digital ICs*
- *Links fabrication process to circuit behavior*

Working in conjunction with the vendor's Analog Workbench or PC Workbench software, the IC Design Tool Kit analyzes the linear characteristics of analog designs. It analyzes designs for linear ICs, mixed-signal ICs, digital ICs, or any combination of these types. The program allows you to enter fabrication-process parameters, so that the simulator can account for parasitic elements and variations inherent in the selected fabrication process. You can assign either nominal values or distribution ranges to the entered parameters. The package includes bipolar and CMOS device models of transistors, capacitors, and resistors. You can also create custom models that contain your own process parameters, and then store the models in a private library. You can use Monte Carlo techniques, evaluate a circuit's sensitivity, and estimate worst-case conditions to calculate the manufacturing yield before you commit your design to silicon. The Smoke Alarm feature lets you analyze the stress levels in your design to improve device reliability. The IC Design Tool Kit costs $13,500 as an option to Analog Workbench, which runs on Apollo, Sun, and HP workstations; it costs $8000 as an option to PC Workbench, which runs on the IBM PC/AT or compatibles.

Analog Design Tools Inc, 1080 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 737-7300.

Circle No 386

WINDOW SYSTEM

- *Allows a virtually unlimited number of windows*
- *Simultaneous output to multiple overlapping windows*

Based on version 10.4 of the X Window System developed by MIT, Opus Systems X is a complete window system for IBM PC/XT and PC/AT systems that run Unix. The window manager provides a consistent user interface for placing, moving, and resizing virtually unlimited numbers of windows, each of which can have title and scroll bars. You can expand or shrink windows and change the placement of and relationships between windows. You can also execute other programs from within the window manager. The common set of system-interface routines makes the system device independent and allows you to transfer your applications from one system to another. The modules include a bit-map editor, terminal emulators, and an analog clock, as well as save

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CIRCLE NO 182

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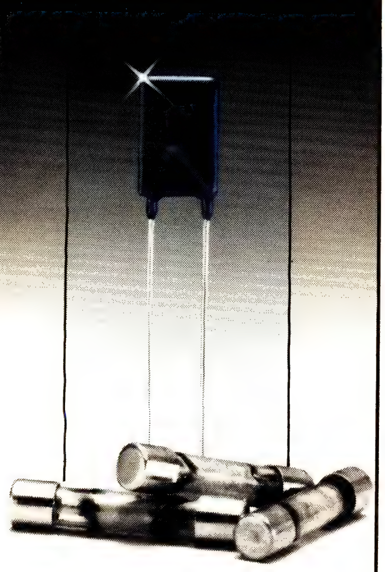

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CIRCLE NO 40

and restore features that facilitate the management of windows. $595.

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Circle No 387

MAP SOFTWARE

- *Source code available for all layers*
- *Enhancements multiply task-to-task data rate by four*

MicroMap 2.1 is a software implementation of the 7-layer Manufacturing Automation Protocol (MAP), which runs on 68020-based systems under the vendor's SYSTEM V/68 operating system. Release 2 contains enhancements that quadruple the effective data rate from one Unix task to another across the cable. Used in conjunction with the vendor's MVME372 Map controller board, the software can achieve an effective data rate of more than 140,000 bytes/sec. In addition to other VME Bus modems, the package now operates with the Series 1300 modems from Concord Communications Inc (Marlboro, MA). Binary license, $600; host/board-resident C source code is also available.

Motorola Inc, Microcomputer Div, 2900 S Diablo Way, Tempe, AZ 85282. Phone (800) 521-6274; in AZ, (602) 438-3000.

Circle No 388

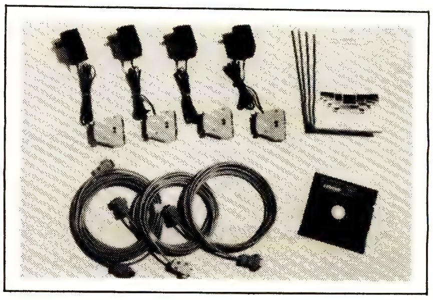
μP-TO-μP COMM

- *Interfaces applications to Multibus II*
- *Provides 50 subroutines for data transfers, interrupt handling*

MPCX is a library of 50 subroutines that provide the μP-to-μP communication that transfers blocks of data and interrupt information in a Multibus II system. These routines provide the interface between application tasks and the message-passing hardware of Multibus II. The library allows communication between multiple processors, each of which runs a different operating system, within the same Multibus II system. The library currently supports the pSOS, VRTX, and Unix System V.2 operating systems. The package includes the board-support package, source code, five object-code licenses, and documentation. $2450.

Microbar Systems Inc, 785 Lucerne Dr, Sunnyvale, CA 94086. Phone (408) 720-9300.

Circle No 389



PC NETWORK

- *Connects to existing serial port*
- *Provides electronic-mail facility*

The SimpleNet LAN system consists mainly of a small hardware module built into the hood of a 25-pin RS-232C connector that plugs into an IBM PC's or compatible's serial port. The system also includes cabling to interconnect LAN modules, and it comes with software that provides both low-level drivers and a menu-driven interface for handling commands at the DOS command level. You can access the network at any time from within any application program. The device-redirection feature allows machines on the network to share disk files and printers. The software provides an electronic-mail facility for communication between users. Two-user system with software and cabling, $595; additional nodes, $99.95 each.

BCSoft Corp, 3261 N Harbor Blvd, Suite B, Fullerton, CA 92635. Phone (800) 262-8010; in CA, (714) 526-5151.

Circle No 390

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Design Concept Through Fabrication in Just 5 Days!

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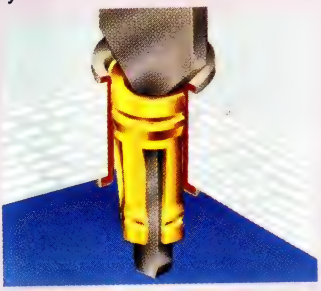

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Stuffing your board is a breeze. All Unilayer II boards are provided with zero-profile Holtite contacts, so you can plug your IC's directly into the board, without soldering and without creating a higher profile. Just plug in your components for smooth skating.

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CIRCLE NO 183

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PC BATCH HANDLER

- *Screen handler lets you create new menus*
- *Script language links existing applications*

BEYOND.BAT extends PC-DOS by providing a screen handler, an editor, and a script language with conditional logic. The script language lets you create applications that link program runs, allowing you, for example, to use word-processor output as spreadsheet input without returning to the DOS command level. The program offers more sophisticated error-handling functions than the DOS batch language does; it provides definable variables on which you can perform arithmetic. Typical applications for the program include setting up the PC for unattended operation, designing data-entry systems that use small scripts to format and direct the input, and creating new menus for easier access to existing applications. $99.

VM Personal Computing, 41 Kenosia Ave, Danbury, CT 06810. Phone (800) 222-8672; in CT, (203) 798-3800.

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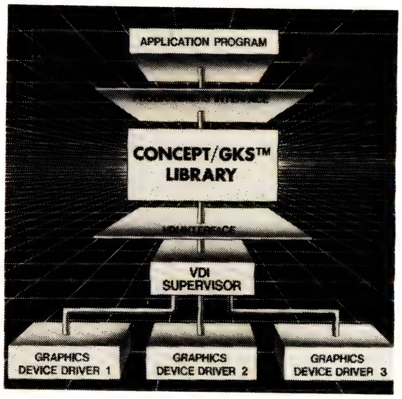
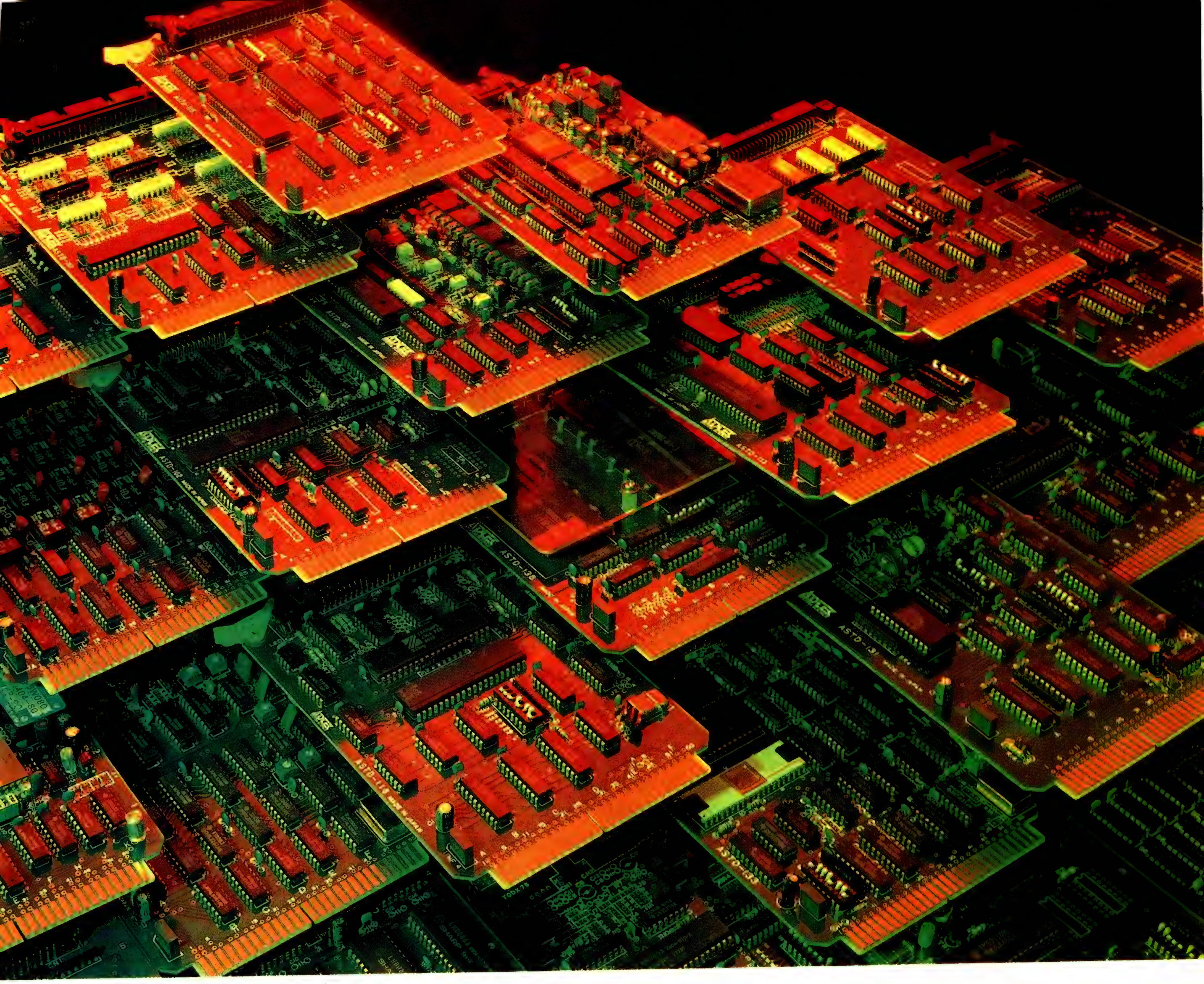


GRAPHICS INTERFACE

- *Implements the ANSI-standard GKS*
- *Works with VME Bus graphics-interface module*

Concept/GKS is an implementation of the ANSI- and ISO-standard graphical kernel system (GKS) for use with the vendor's MVME390A graphics interface module in VME Bus systems. The GKS library of standard functions lets you write applications software that is device independent, eliminating the need to develop your own drawing algorithms. Further, your software will be transportable to other graphics systems that use the GKS. This graphics kernel operates under the vendor's System V68 or VersaDOS operating systems, and you can obtain bindings to the Fortran-77 or C languages. The single-unit binary license price includes the Concept/GKS library (configured to work with CRTs) and one hard-copy device driver; drivers for a variety of



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Kanagawa 240 JAPAN
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printers and plotters are available. $1750.

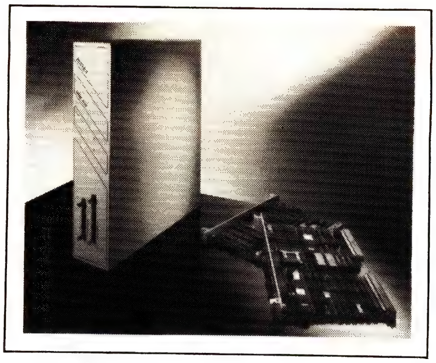
Motorola Microcomputer Div, 2900 S Diablo Way, Tempe, AZ 85282. Phone (602) 438-3500.

Circle No 392

EMULATOR

- *Supports most 8-bit μPs*
- *Includes memory- and hardware-breakpoint facilities*

The Mime-600 emulator connects to a PC or host computer to provide program debug facilities for most popular 8-bit μPs. In addition to four breakpoint/trigger control tag-bits for each of the μP's memory locations, the emulator has four 48-bit hardware breakpoint comparators. You can break on the nth occurrence of a comparator's break condition, or on logical combinations or logical sequences of breakpoint conditions. The emulator has an 8k×48-bit trace memory, which you can reconfigure to 4k×96-bits for time-stamped trace results. The emulator has a total memory map of 16M bytes, with 256k bytes of relocation RAM, and another 256k bytes of shadow memory. During program development on the host computer, the emulator provides a transparent link between the computer and a terminal. After developing your program, you can download program code and symbol tables to the emulator for use in debugging. £4300, including a target adapter board for one μP; additional target adapter boards, £1790.



Pentica Systems Ltd, Station Industrial Estate, Oxford Rd, Wokingham, Berks RG11 2YQ, UK. Phone (0734) 792101. TLX 848210.

Circle No 393

IEEE-488 DRIVER

- *Links PCs to IEEE-488 instruments*
- *Works with PC-DOS and STD-DOS*

DOS.GPIB is an installable device driver that lets a PC communicate with peripherals connected to an IEEE-488 bus. The driver works with the vendor's hardware IEEE-488 bus controllers for IBM PCs, PC/XTs, PC/ATs, PS/2-30s, and compatibles, as well as with the ZT/2 controller for the PS/2 Models 50 and 60. You can also use the driver with the vendor's ZT 8847 controller for STD Bus systems run-

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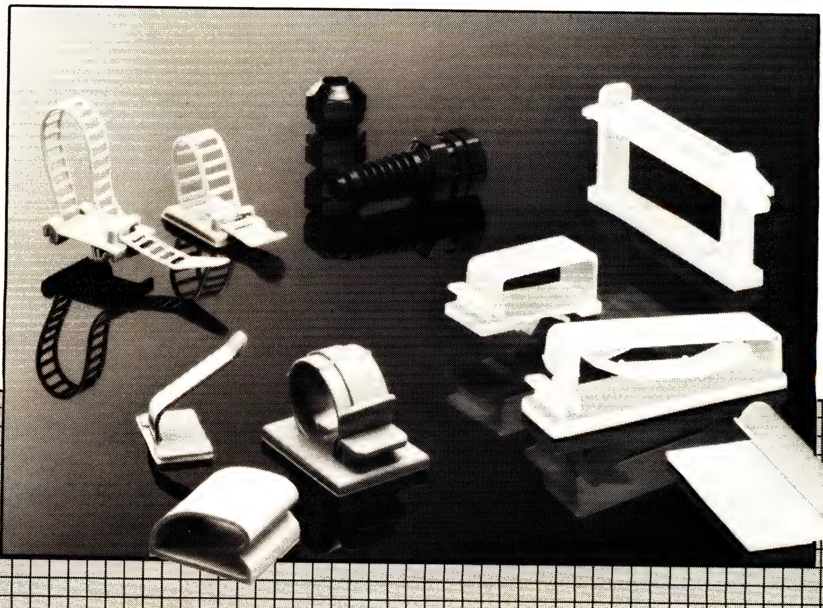

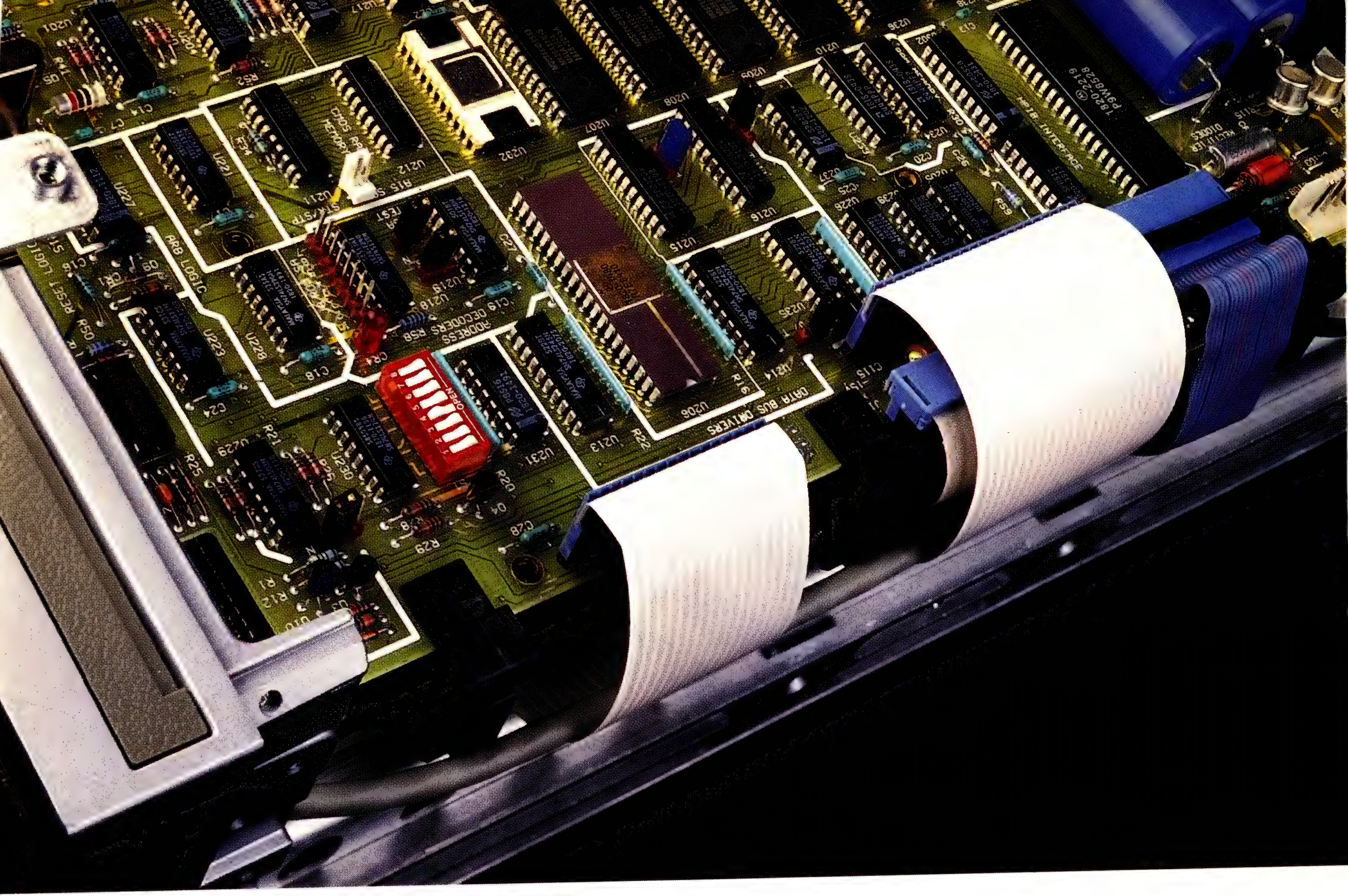

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CIRCLE NO 185

HIGH SPEED

256K

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AT28HC256

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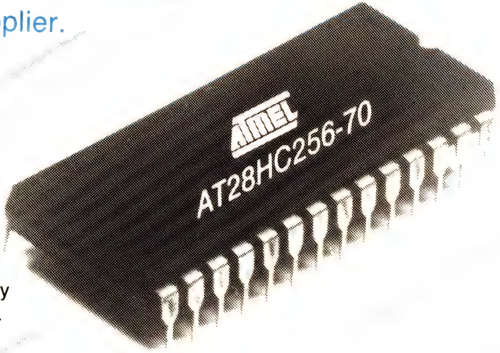

AT28C256

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Self-timed Nonvolatile Page Write Cycle
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Density	Part Number	Organization	Speed (ns)								Package				Mil
			70	90	120	150	200	250	300	350	P	D	L	J	883
256K	AT28C256	32K x 8				X	X	X	X	X	X	X	X	X	X
256K	AT28HC256	32K x 8	X	X	X						X	X	X	X	X

P-Plastic; D-Ceramic Dip; L-Leadless Ceramic; J-Plastic j-leaded

The standard features on all ATMEL E^{2}PROMS such as $\overline{\text{DATA}}$ polling, address and data latches, chip clear and internal error correction are also on these two devices. Of course all ATMEL E^{2}PROMS operate from 4.5V to 5.5V at temperatures from −55C to 125C. They are also Mil Std 883C compliant. From 4K to 256K, ATMEL E^{2}PROMS have the features and performance needed to make your design a success.

ATMEL's high speed CMOS E^{2}PROMS are available now in high-volume production quantities. ATMEL, the leader in CMOS E^{2}PROM technology.

ATMEL

2095 Ringwood Avenue, San Jose, CA 95131
TEL: (408) 434-9201 FAX: (408) 434-9825

CIRCLE NO 186

ning under the STD-DOS operating system. The driver lets you access devices on an IEEE-488 bus from application programs written in Basic, C, Pascal, Fortran, and assembly language; it also gives preexisting development tools and application programs access to the IEEE-488 controllers without requiring any additional programming. By using this driver, you can develop your application programs on a PC or PS/2 machine and easily transfer them to an STD Bus system, which is better suited to a harsh environment. The price of the vendor's ZT 1444/1488A controller includes linkable drivers for Basic and Compiled Basic. Linkable drivers for assembly, C, and Pascal are available as options. These linkable drivers are more efficient than the installable DOS.GPIB, and you should use them if your application requires high data-transfer speeds. DOS.GPIB, $250; Assembly, Pascal, and C linkable drivers, $50 each (with purchase of controller).

Ziatech Corp, 3433 Roberto Ct, San Luis Obispo, CA 93401. Phone (805) 541-0488. TLX 4992316.

Circle No 394

OPERATING SYSTEM

- *Integrates RT multitasking with MS-DOS*
- *Includes sample drivers*

Suitable for use on IBM PC/AT and compatible computers, the RT/iX operating system allows you to execute real-time multitasking operations under MS-DOS (version 3.0 and up). The operating system controls application programs written in C, and after program execution MS-DOS remains available for the user without any rebooting. All access to mass storage remains under the control of the MS-DOS file manager, allowing you to transfer data from the application program to standard MS-DOS-based programs. The system comes on a 3½- or 5¼-in. disk, and includes source code for sample drivers, which you can use for interrupt-driven or polled systems. Around DM 1000.

Kontron Messtechnik, Oskar-von-Miller-Strasse 1, 8057 Eching/Munich, West Germany. Phone (08165) 77601. TLX 526719.

Circle No 395

Kontron Electronics Inc, 630 Clyde Ave, Mountain View, CA 94039. Phone (415) 965-7020. TWX 910-378-5207.

Circle No 396

VAX BACKUP

- *Eliminates disk-file fragmentation*
- *Lets you back up optical-drive contents*

Automatic Backup lets you create a command file that defines the time, frequency, and characteristics of the file backups you need for a VAX/VMS system. The program executes the backups automatically. The latest release includes enhancements that let you back up the contents of optical WORM disks as well as magnetic disks. You can back up all accounts or selected accounts; you can also skip the backup of accounts or files that change only rarely. The program's defragmentation option compresses and consolidates the space occupied by any or all accounts; an automatic modem controller can turn modems on specified ports on and off. You can skip backups on days defined as holidays, and you can provide similar special handling for the modems. Each time the program schedules a backup job to wait, to start execution, or to prepare for the next scheduled execution, it creates an entry in a history log to aid system managers in performing system-security reviews. From $377, depending on VAX configuration.

Syco System Communications Inc, Box 838, Leominster, MA 01453. Phone (617) 534-6499.

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CIRCLE NO 43

NOISE CANCELER

- *Eliminates low-frequency, repetitive, acoustical noise*
- *Requires users to wear headphones*

The NCT 2000 analyzes low-frequency acoustical noise and then generates a noise-canceling signal that is 180° out of phase. The device works best at frequencies below 600 Hz. It cannot eliminate environmental noise. Instead, users must wear noise-canceling headphones. You can upgrade the standard 2-channel unit to eight channels. $15,000 to $25,000.

Noise Cancellation Technologies Inc, 98 Cutter Mill Rd, Suite 275N, Great Neck, NY 11021. Phone (516) 466-1060. TWX 910-240-1097.

Circle No 413

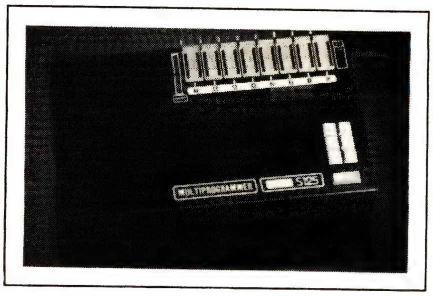
GANG PROGRAMMER

- *Gang-programming adapter outperforms older model*
- *Upgrade kit available*

The Gangpak V7.1 gang-programming adapter for the vendor's 29B, 29A, and 100A device programmers can program and verify eight EPROMs at once. It handles 240 EPROM types. When used on certain types, the new adapter is 5.5 times faster than the model it replaces. Gangpak V7.1, $1650; upgrade kit, $325.

Data I/O Corp,, Box 97046, Redmond, WA 98073. Phone (206) 881-6444. TLX 152167.

Circle No 414



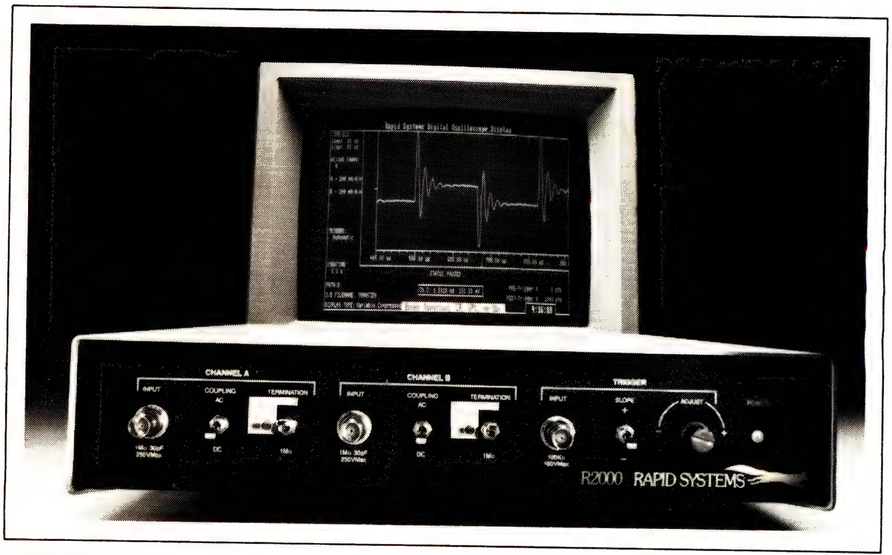
GANG PROGRAMMER

- *Programs eight EPROMs or EEPROMs from memory*
- *Programs 4-device set from master PROMs*

The S125 gang programmer programs most 28-pin EPROMs and EEPROMs and uses no personality adapters. The programmer can copy the same data into eight devices (or optionally into 16) at the same time. Or it can simultaneously program as many as four devices (eight, optionally) with different data from master PROMs to accommodate 16- and 32-bit word widths. The device has a 64k-byte data memory. Options include adapters for eight additional devices, for 32- and 40-pin devices, and for 3-voltage devices. $695.

Bytek Corp, 1021 S Rogers Circle, Boca Raton, FL 33431. Phone (800) 523-1565; in FL, (305) 994-3520. TLX 4998369.

Circle No 415



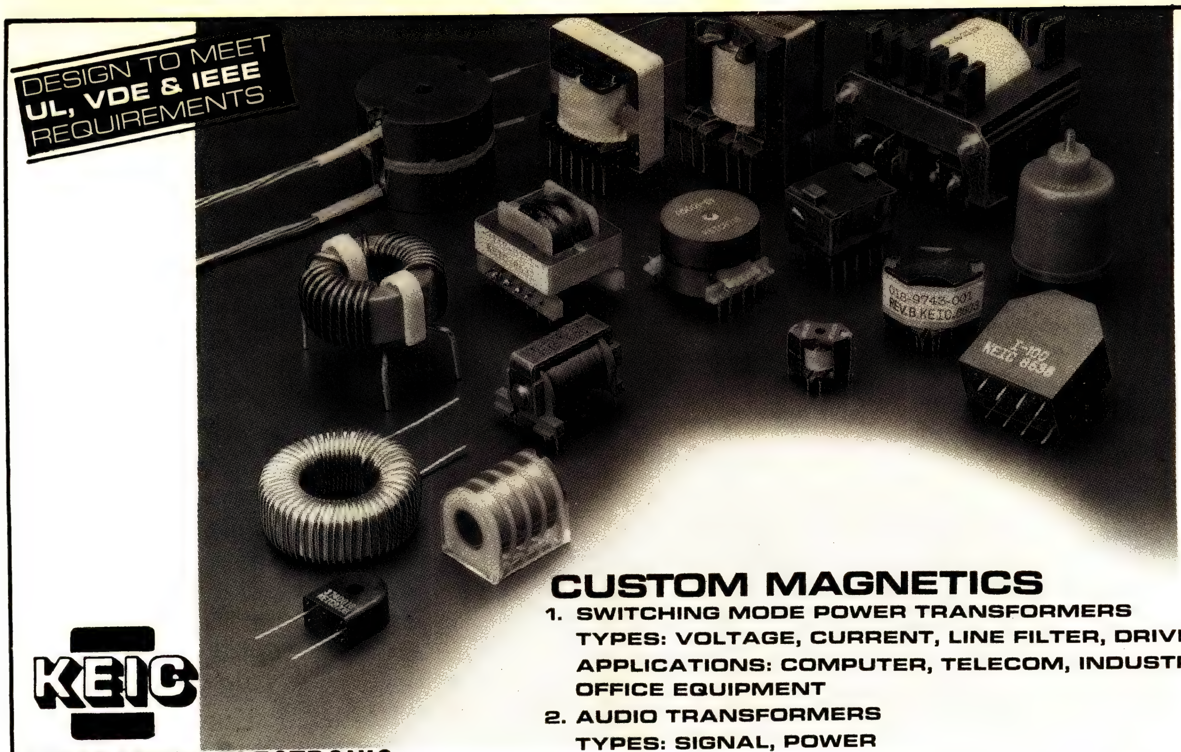
IBM PC SCOPE

- *Digitizes at 20M samples/sec*
- *Has two 64k-byte sample memories*

The R2000 2-channel, 20M-sample/sec digital oscilloscope uses an IBM PC for display and storage. The scope can simultaneously sample both channels at 20M samples/sec with 8-bit resolution, and it records into two 64k-byte memories. Input sensitivity ranges from 10 mV/div to 50V/div. The instrument's front panel features switch-selectable 1MΩ and 50Ω inputs. Options include FFT software and 128k-byte capture buffers. $3495.

Rapid Systems Inc, 433 N 34th St, Seattle, WA 98103. Phone (206) 547-8311. TLX 265017.

Circle No 416



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CIRCLE NO 198

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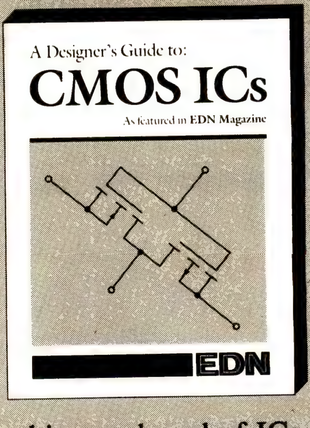

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SPECTRUM ANALYZER

- *Spectrum-analyzer module works with digitizer*
- *Modules fit firm's 70000 system*

Two modules for the HP 70000 instrument system permit 100-Hz to 22-GHz swept spectrum analysis (analysis performed in one contious sweep) and 20M sample/sec, 10-bit digitizing. The HP 71210A spectrum-analysis module has −133-dBm sensitivity at 22 GHz (10-Hz bandwidth) and ±2-dB amplitude accuracy from 2.7 to 22 GHz; it requires the HP 70908A RF front-end module, which provides a fundamental-frequency mixer and tracking preselector. The HP 70700A digitizer has a 3-MHz analog bandwidth and can either stand alone or work in conjunction with the spectrum-analyzer module. You can control as many as four digitizers manually and as many as eight under program control. Each digitizer module has a 256k-sample memory and built-in math functions. The module's time resolution is 50 nsec; the manufacturer claims that the module exhibits no intersample dead time. HP 71210A microwave spectrum analyzer, $69,500; required HP 70908A RF section, $35,200. Delivery, 18 weeks ARO. HP 70700A digitizer, $7500. Delivery, 12 weeks ARO.

Hewlett-Packard Co, Inquiries Manager, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

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CIRCLE NO 188

and 500 mA, respectively. The unit comes in a 9×9×10-in. case and weighs 10 lbs. The company also supplies a fixture for hockey-puck devices. $2500.

Brindle & Associates Inc, 5901 Warner Ave, Suite 69, Huntington Beach, CA 92649. Phone (714) 847-4738.

Circle No 418

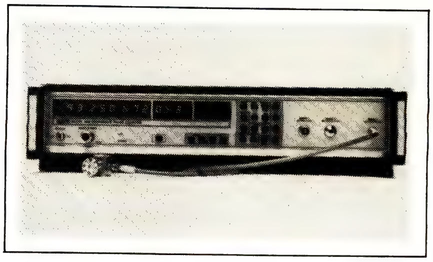
MATE COUNTER

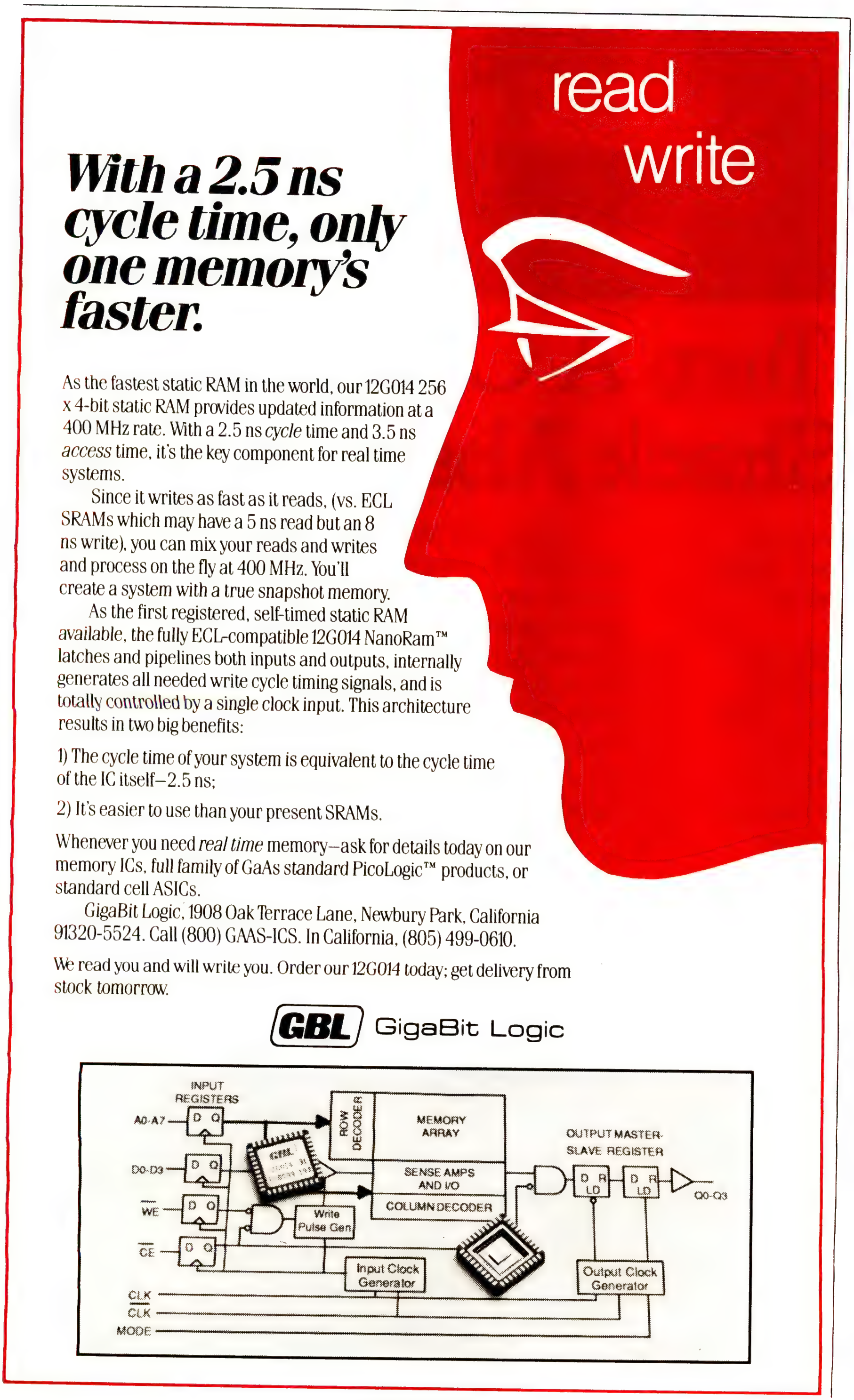
- *Counters conform to Air Force standard*
- *Family comprises pulsed and CW counters*

Models 535 and 538 are MATE-compatible versions of two of the vendor's families of microwave counters. (MATE is the Air Force's modular automatic-test-equipment standard.) The 535 and 538 are continuous-wave (CW) counters with frequency coverage of dc to 18 GHz and dc to 26.5 GHz, respectively. Models 585 and 588 are capable of counting CW, pulsed, and time-varying signals to 18 and 26.5 GHz, respectively, with optional coverage to 110 GHz. The counters' YIG (yttrium iron garnate) preselectors offer 10W burnout protection. Model 535, $5950; Model 538, $6950; Model 585, $12,700; Model 588, $14,700. Delivery, eight to 10 weeks ARO.

EIP Microwave Inc, 2731 N First St, San Jose, CA 95134. Phone (401) 946-5700. TWX 910-338-0155.

Circle No 419





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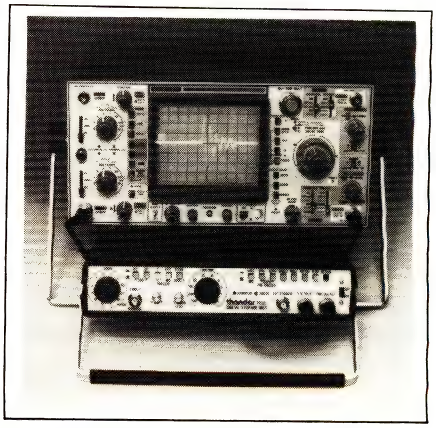
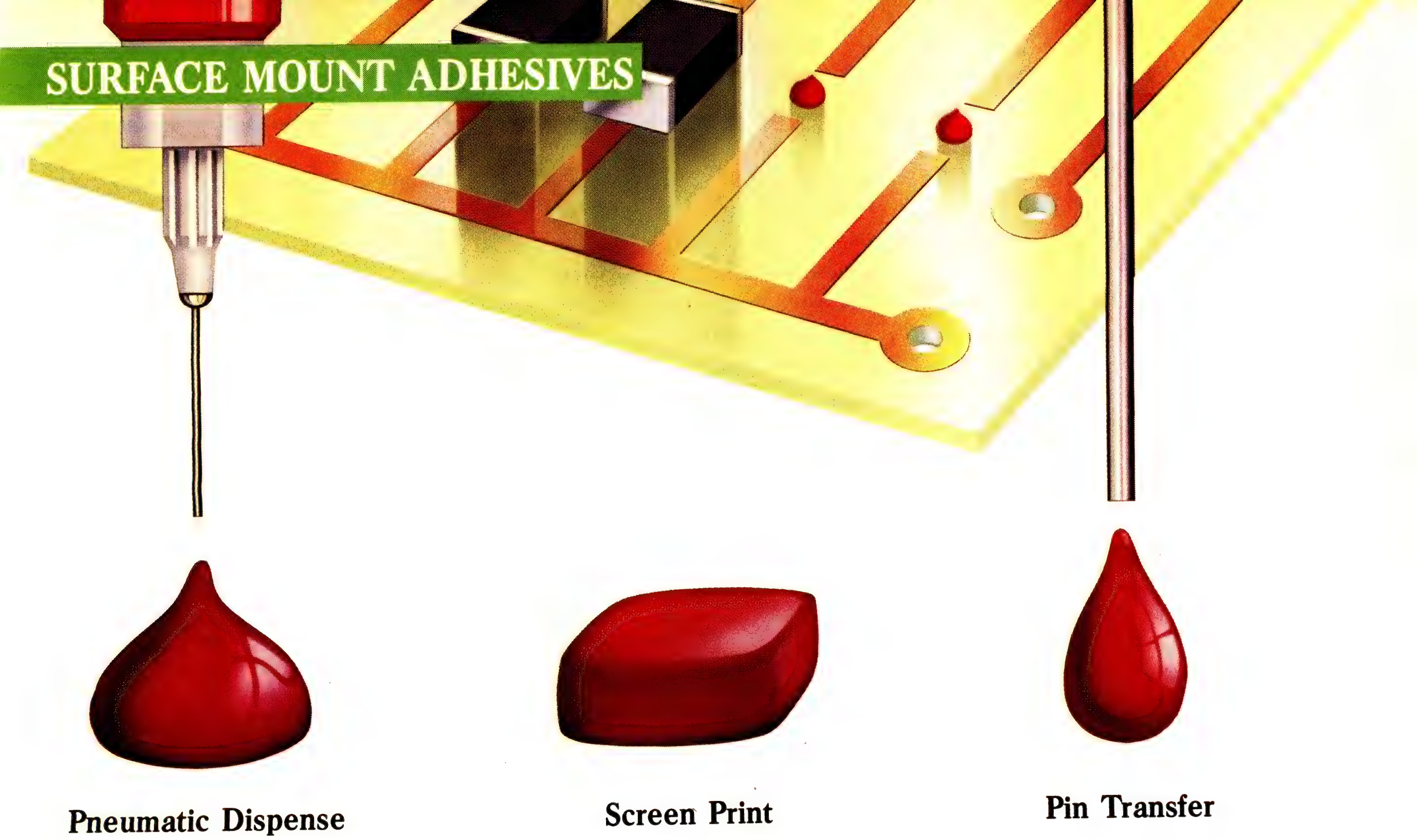
CIRCLE NO 45



SCOPE ADAPTER

- *Provides conventional scopes with digital storage*
- *Operates in single-shot, refresh, or roll mode*

The TD201 scope adapter allows you to add digital storage facilities to a conventional real-time oscilloscope. The unit digitizes the input with 8-bit resolution and stores the digitized trace in a 1k-byte trace memory. You can select sampling inter-



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CIRCLE NO 189

vals of between 5 μsec and 5 sec, giving corresponding horizontal timebase ranges of 0.5 msec/div and 500 sec/div. The unit's effective storage bandwidth is dc to 20 kHz. You can operate it in single-shot, refresh, or roll modes. It has both internal and external trigger facilities, and you can display 0, 50, or 100% pretrigger information. The instrument also has a real-time scope mode with a bandwidth of dc to 200 kHz. Its input-sensitivity ranges are between 5 mV/div and 20V/div, and it has a maximum input-voltage capability of 250V dc or ac peak (or 250V rms for 1 minute). The scope adapter operates from disposable or rechargeable batteries or from an ac line adapter. Its battery-backup feature retains data in the trace memory for as long as four years. £195.

Thandar Electronics Ltd, London Rd, St Ives, Huntingdon, Cambs PE17 4HJ, UK. Phone (0480) 64646. TLX 32250.

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- *Offers 4-wire, guarded outputs*

The Model 263 calibrator works with electrometers and picoammeters. The unit supplies current from 2 pA to 20 mA, charge from 20 pcoulomb to 20 μcoulomb, and voltage from 200 mV to 20V. It measures resistance from 1 kΩ to 100 GΩ. For low-current calibrations, the unit offers 4-wire outputs. An IEEE-488 interface is standard. $3495.

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. TLX 985469.

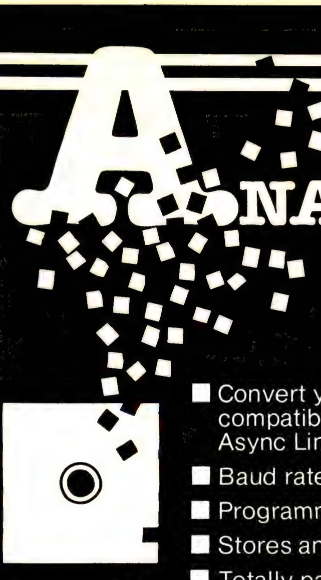
Circle No 421

BOARD ATE

- *ATE combines in-circuit and functional testers*
- *Uses Macintosh Plus as workstation*

The 850 F/I board-level ATE system performs both functional and in-circuit testing. The tester handles μP boards with clock speeds to 40 MHz and can invoke onboard diagnostic routines. The device has a digital capture memory of 8k bits/pin max, and its hardware includes a 16-channel, 8-MHz logic analyzer. A Macin-

A LINK ANALYZER



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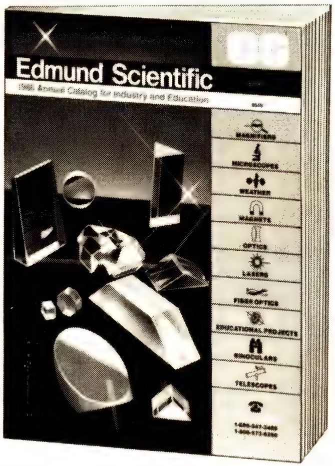

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Power MOSFET Makers Boost Electrical Specs

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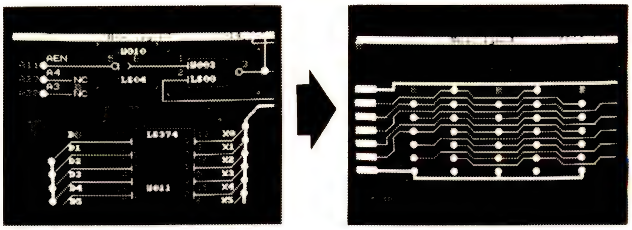

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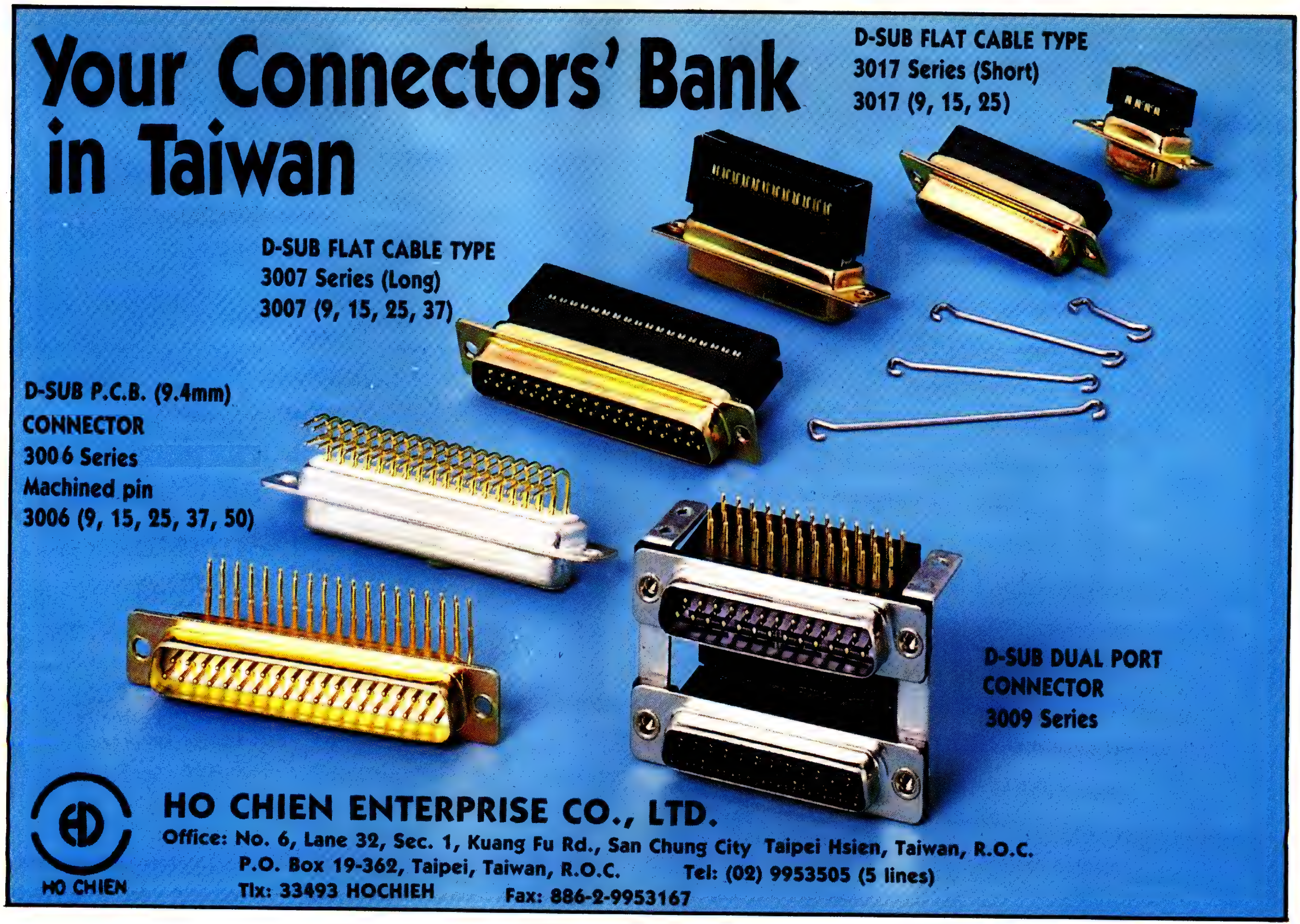

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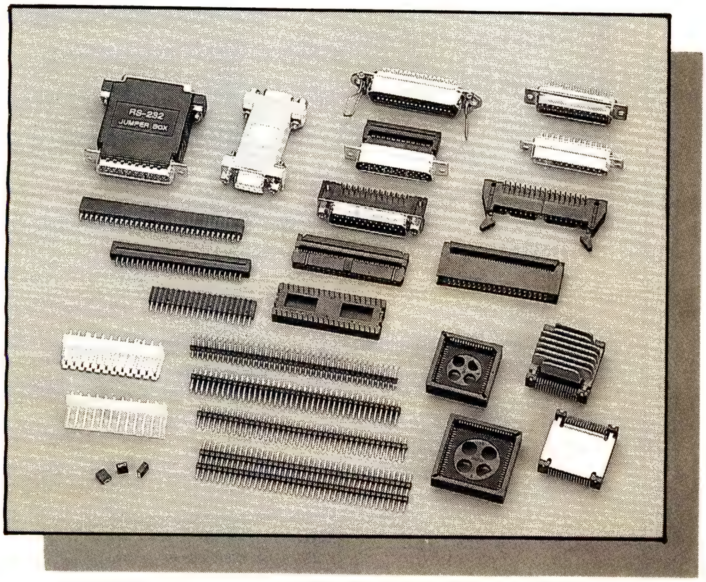
CIRCLE NO 199

OUPIIN Sourcing Connectors & Chip Sockets?



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CIRCLE NO 200

tosh Plus controls test-program development. The system's software includes automatic vector-translation routines. Its hardware options include a counter-timer module, IEEE-488 links, and a custom functional-test module for user-designed circuitry. 850 F/I, $263,000 typ; F/I retrofit for existing 850s, $20,100.

Zehntel Inc, 2625 Shadelands Dr, Walnut Creek, CA 94598. Phone (415) 932-6900. TWX 910-385-6300.

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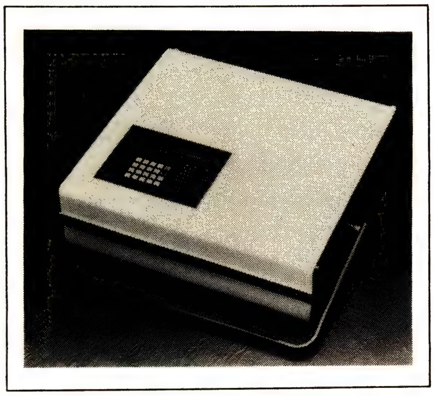

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The CS-1010 Winspector is a Winchester disk-drive tester that works with three interfaces: ST506, SCSI, and ESDI. The tester comes with built-in test programs and exercises the drive's logic, control, and status lines. It also measures timing parameters. Its options include RLL-encoded data and 5-MHz or 7.5-MHz data rates. $7000 to $8450.

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The 850F/I is an upgrade of the firm's earlier 850 in-circuit tester; the upgrade includes some functional-test capabilities. For example, the tester can invoke and analyze the results of built-in tests present on µP-based boards. It can handle µPs having clock speeds as high as 40 MHz, and it captures data at 10 MHz. The tester's 16-channel, 8-MHz logic analyzer has an 8k-sample memory and a 100-MHz counter/timer. The tester uses an Apple Macintosh Plus for programming. You can append IEEE-488 instruments to the tester. $263,000 (800 nodes); F/I retrofit, $20,100.

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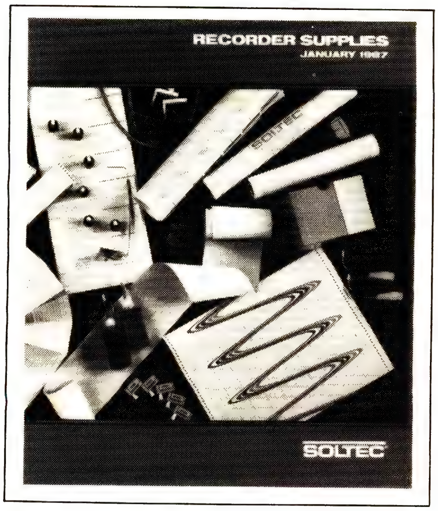

Booklet features recorder supplies

The 20-pg catalog, *Recorder Supplies*, provides a listing of supplies for the company's line of recorders. Photographs of the recorders, as well as detailed drawings of the supplies, help you order the supplies you need. A cross-reference guide that lists the old and new catalog numbers is also included.

Soltec Corp, Sol Vista Park, San Fernando, CA 91340.

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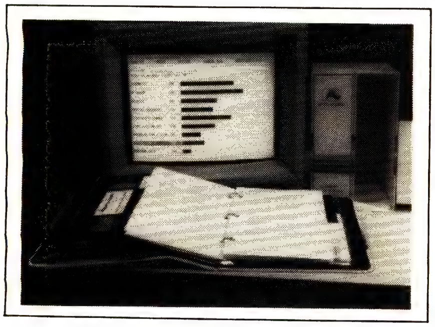

Software eases selection of CAE/CAD

The Buyers' Guide kit includes a videocassette on how to evaluate a CAE/CAD purchase, an extensive manual on how to shop for CAD, and an item-by-item check list for comparison shopping. It also contains a software package that allows you to compare a wide range of CAE/CAD software products. The software combines the elements of spreadsheets and rational decision theory to aid you in choosing from a variety of products. It features a context-sensitive help function, a tutorial, and a windowed environment. $99.

Aptos Systems, 10 Victor Square, Suite 200, Scotts Valley, CA 95066.

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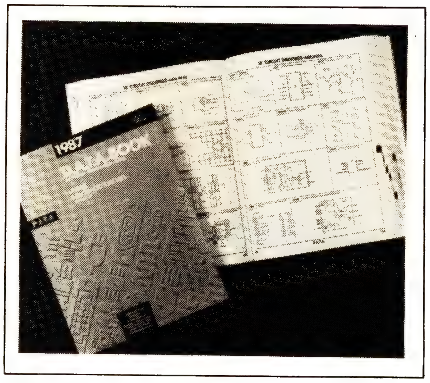

IC product book extends coverage

The 38th edition of *Linear ICs* presents information on more than 15,000 linear ICs from 153 manufacturers. It has an expanded op-amp section that lists single, dual, triple, and quad devices, including programmable, ultralow noise, and biFET types. The book covers many analog devices, such as amplifiers, voltage references, motor-control circuits, phase-locked-loop devices, RF/IF amplifiers, sensor circuits, timers, transistor arrays, wideband amplifiers, and voltage comparators. It features circuit drawings and device outline drawings, a generic index that highlights surface-mount packages, a military-commercial cross-reference section, and manufacturer information. A subscription, which includes two semiannual editions, costs $110.

DATA Inc, Box 26875, San Diego, CA 92126.

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Vector signal generator and vector analyzer examined

Introductory Operating Guide to the HP 8780A Vector Signal Generator and *Introductory Operating Guide to the HP 8980A Vector Analyzer* supplement the information that appears on the two products' technical data sheets. The 32-pg guide to the vector signal generator (Publication 5954-6368) reviews vector modulation and elaborates on modulation capabilities—digital PSK/QAM, FM, amplitude/scalar, and combinations of simultaneous modulations. Application examples include shaped-pulsed modulation and frequency-hopped signals. The 32-pg document on the vector analyzer (Publication 5954-6369) examines the three basic operating modes of the 350-MHz baseband analyzer—vector, constellation, and time modes. It also covers special measurement routines and instrument familiarization, and describes applications setups. Several appendixes cover subjects such as vector demodulator theory and IEEE-488 codes for programming.

Hewlett-Packard, 1820 Embarcadero Rd, Palo Alto, CA 94303.

Circle No 429

Packet contains facts about EMS products

The EMSPAK/D package combines available literature on the EMS (Energy Management Series) power-module products. Data sheets are included for products with current-handling capabilities ranging from 50 to 300A and 1000 to 1200V. Also included in the package is the EMS Selector Guide (SG114), along with data sheets for the 22 devices in the series.

Motorola Inc, Literature Distribution Center, Box 20924, Phoenix, AZ 85063.

Circle No 435

App notes address problems with dual-port memory

These two application notes deal with the problems and tradeoffs that occur when designing systems using dual-port memory. The first note, *Some Practical Thoughts about the Value of Dual-Port RAM*, looks at the cost and performance tradeoffs between SSI/MSI dual-

Text continued on pg 332

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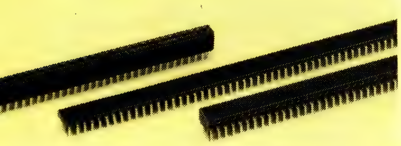

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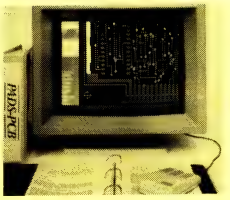

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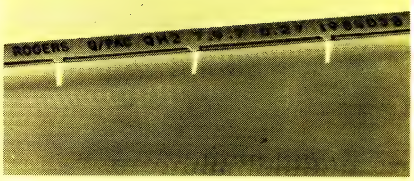

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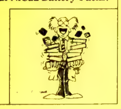
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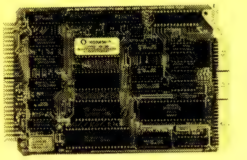

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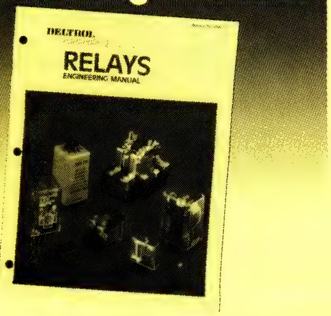

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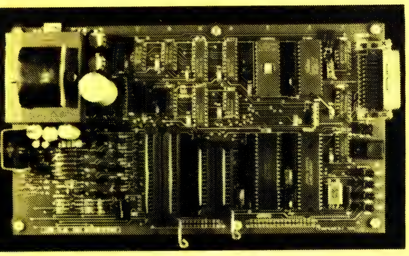

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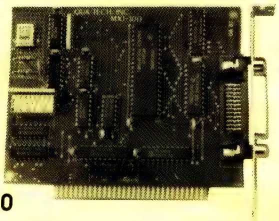

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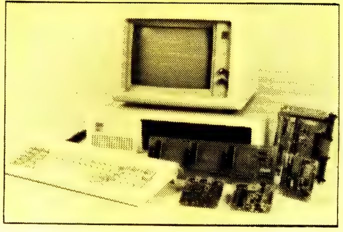

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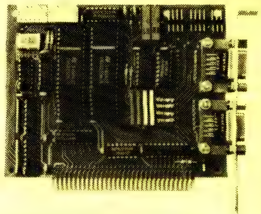

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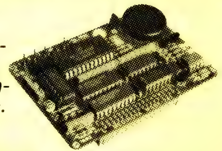

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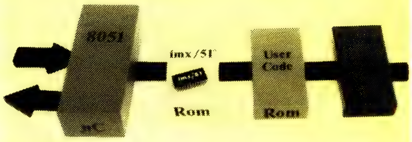

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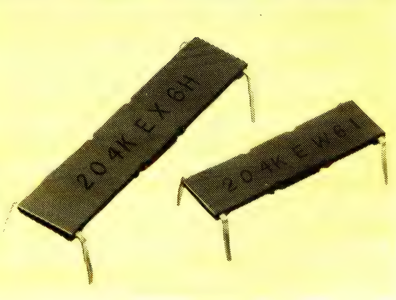

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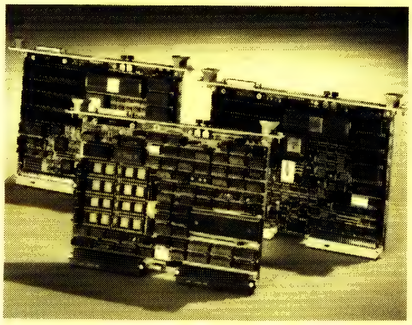

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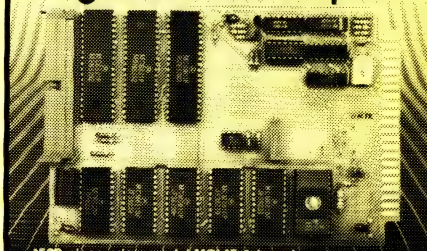

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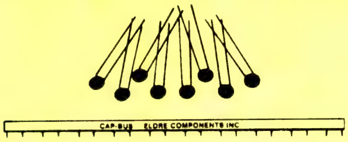

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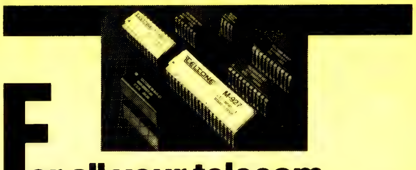

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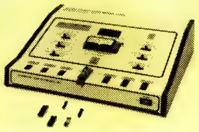

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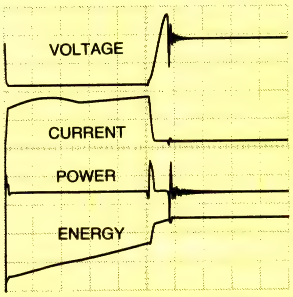

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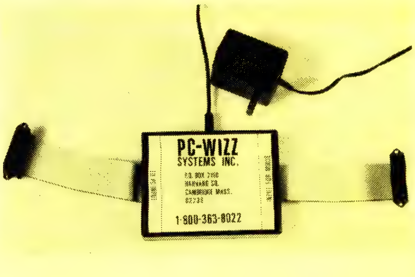

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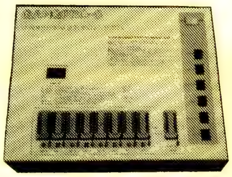

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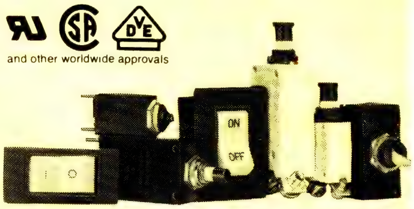

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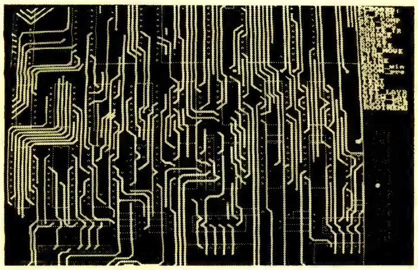

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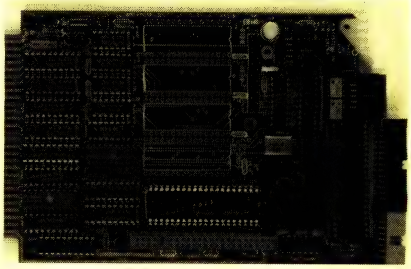

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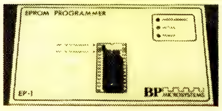

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HF8-4

CIRCLE NO 191

port mechanizations and monolithic dual-port RAM. The second note, *Cascading Dual-Port RAM,* solves the problems of expanding dual-port RAMs for wider and deeper operations.

Vitelic Corp, 3910 N First St, San Jose, CA 95134.

Circle No 430

Catalog aids in choosing ceramic filters

Ceramic EMI/RFI Filters features descriptions of circuit configurations and functions. It includes a filter-selection flow chart, installation guidelines, definitions of terms, and military test procedures. Catalog FD-129 is divided into dc-rated and ac/dc-rated sections. Subcategories are defined by circuit function. Within each general circuitry category, devices are shown in order of current and voltage rating.

Sprague Electric Co, Technical Literature Service, Box 9102, Mansfield, MA 02048.

Circle No 431

Directory lists more than 1700 computer programs

You can now obtain the 1987 edition of the *Directory of Computer Software* from the National Technical Information Service of the US Department of Commerce. Each of the 1700 federal common-use programs is tested and proven for both mainframe and μCs. The directory is keyed two ways: by subject categories, which list brief program abstracts; and in indexes by agency, accession number, and subject. These indexes contain all computer programs in the directory; the hardware and language indexes comprise all entries for a limited number of programs. The directory includes 100 new programs from the National Energy Software Center. $48.

US Department of Commerce, National Technical Information Service, 5285 Port Royal Rd, Springfield, VA 22161.

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Signal-sources bulletin

This 4-pg technical bulletin describes the Series 6150A AM/FM signal sources. It details the modulation, harmonics, and stability of the instruments, which are solid-state oscillators employing a GaAs FET as the active element. The pamphlet also contains specifications and a description of the vendor's 6140 GPIB adapter.

Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401.

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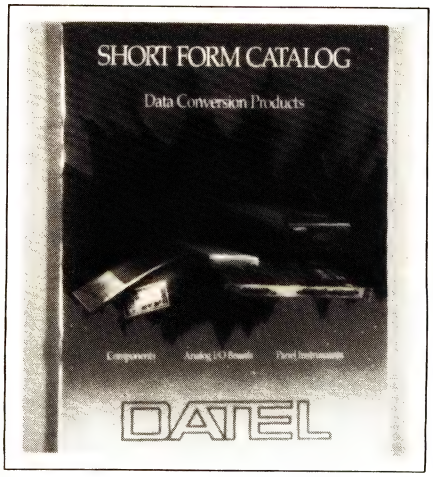

Data-conversion products section expanded

This 48-pg short-form catalog includes components, analog-I/O boards, panel instruments, and additions to the vendor's line, such as video-speed flash converters, a smart Multibus board for temperature measurements, and evaluation boards for high-speed A/D converters. The catalog also provides information on high-reliability/military tests and products that conform to MIL-STD-1772.

Datel, 11 Cabot Blvd, Mansfield, MA 02048.

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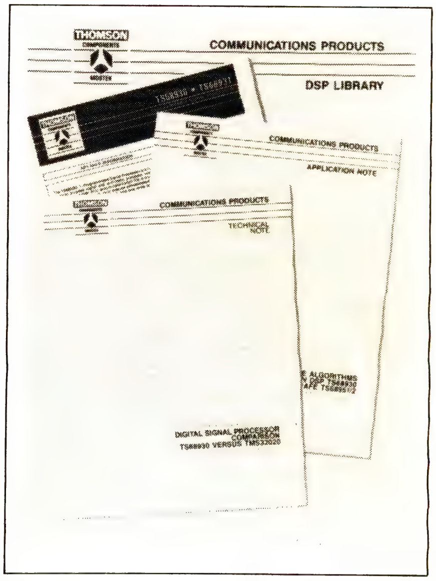

A comprehensive look at a DSP chip

This literature set includes a 52-pg data sheet on the TS68930 digital signal processor. You also get a comparison of the TMS32020 and TS68930 DSP chips, which includes a characteristics benchmark, instructions, and an I/O configuration. A TS68930 DSP module library provides a list of software modules and macros for multiplication and accumulation, double-precision shifts, and FFTs. And a 45-pg application note features sample listings for DSP algorithms in real-time applications that use the TS68930 DSP chip and the TS68950/1/2 modem analog front-end chip set.

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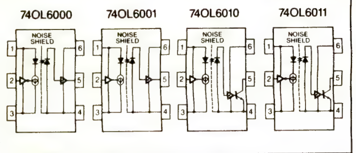

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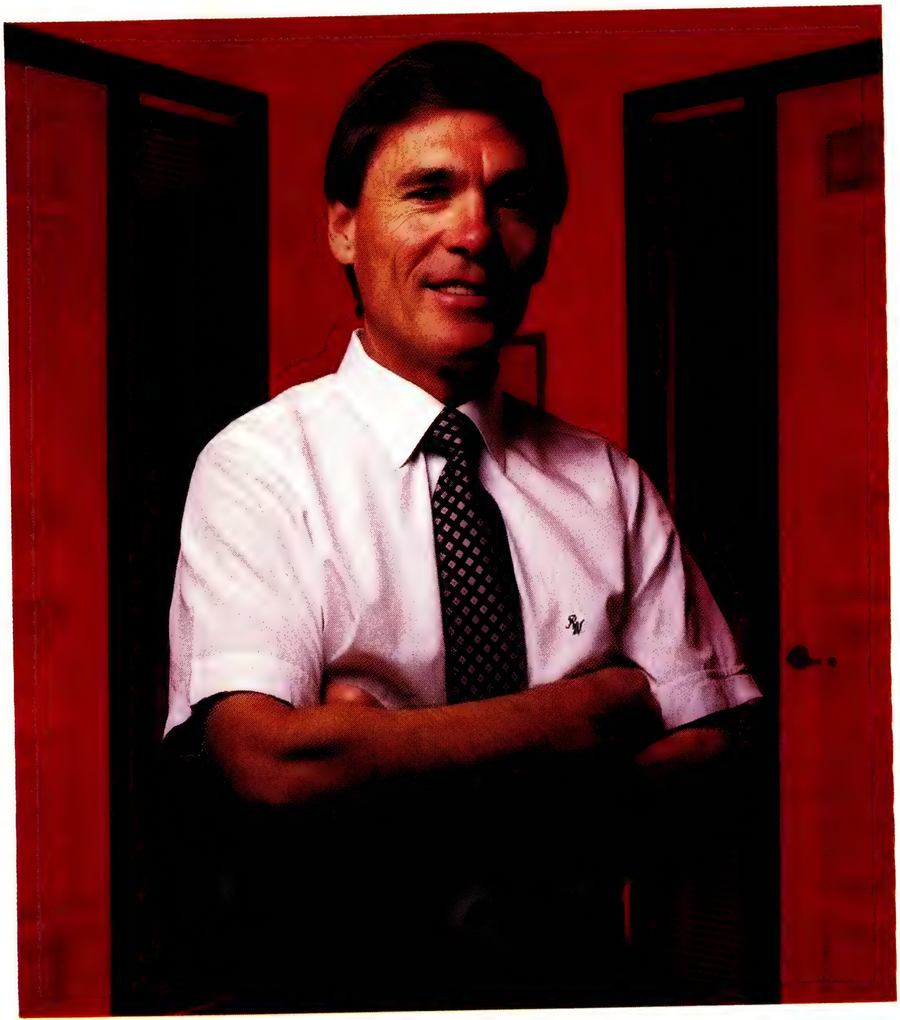
Deborah Asbrand, *Associate Editor*

Engineers at one company share the pride and the profits of successful product design



***Former engineer Randy Wilson** used $13,000 of his savings to found Wilson Laboratories in 1973.*

In 1972, Randy Wilson was working as a field-service manager for a Los Angeles, CA, manufacturer of high-performance tape and disk drives. To make his job easier at customer sites, he designed a piece of equipment to test ½-in. tape drives. Customers began to notice the portable, suitcase tester and to inquire about ordering one. Wilson notified his employer of the customer interest in the tester, and the company repackaged his design for commercial production. In 90 days, customers bought 100 of the testers for $1000 each.

Wilson felt proud that his idea had generated so much revenue for his employer. He hoped that the product's success might result in a raise. A short time after the company put the tester into production, Wilson got his reward. "The president of the company came to me, shook my hand, and said that it was through the efforts of people like me that the company could grow. I think I got a 7% raise that year."

Several years later, Wilson finally found a way to profit from the experience. As president of his own start-up company, Wilson Laboratories, he was ready to begin hiring a full-time engineering staff but couldn't match the high salaries and generous benefit packages that established companies offered top designers. What he could afford, though, was to offer engineers a percentage of sales of the products they designed: If the products were profitable, the engineers would stand to earn thousands of dollars in royalties; if customer interest in the products was minimal, the engineers' earnings would be as well.

The cash-for-designs plan worked. Since Wilson Laboratories began the royalty program in 1980, engineers at the privately held company have pocketed cash royalties of more than $500,000. The company has been equally flush. In its 15-year history as a manufacturer of disk-drive test equipment, Wilson Labs has shipped more than $30 million in products and has never had an unprofitable year. Wilson credits the royalty program with helping to minimize the problems of poorly designed or late-to-market products and high engineering turnover that plague other companies. By all accounts, the program has become a strong, albeit imperfect, incentive that benefits both the engineers and the company.

Cause and effect

For Wilson, the experience at the tape- and disk-drive manufacturer was just one more occasion when the amount of effort he put into an endeavor was not reflected in his financial reward. Previous engineering jobs at Burroughs, Scientific Data Systems, Xerox, and Pertec had left him feeling similarly detached from his work. The absence of any correlation between work and salary frustrated him. Shortly after designing the tester, Wilson left the company and with a partner bought a third-party maintenance franchise. Working for himself was exhilirating and exhausting.

"There was no limit to what was available," Wilson says. "I could work as hard as I wanted to, and make as much money as I wanted to." The franchise kept its service fees low, and when word of its affordable prices spread, the franchise's telephone began to ring. The two men took all the calls, sometimes making service calls in the middle of the night. "That first year, I think I put 54,000 miles on my little Ford Pinto station wagon," Wilson remembers. He also doubled his income.

Despite Wilson's testimony to the power of financial incentives, the royalty program at Wilson Labs didn't materialize until several years after he'd founded the company. In fact, the program might not have developed at all had Wilson not needed a way to attract top engineers to his fledgling concern. From 1973 to 1980, Wilson's profits remained too slim to allow him to hire full-time, salaried engineers. Instead, he relied on the skills of employed engineers who were willing to design his company's products on a free-lance basis. Wilson found his early dependence on moonlighters advantageous. By drawing on the area's pool of engineering talent, he got to know some of Orange County's most talented designers.

"Seeing these first-class designers, I'd think that I'd love to have them come to work for me full-time, but what did I have to offer them?" Wilson recalls. "These guys . . . were trying to build a career. I had 7000 square feet of space and $1 million in sales. How could I attract them?"

The answer came in 1980 when Wilson began negotiating with Jim Dietz, then a design-group supervisor for GTE in Anaheim, CA. When a marketing representative for Wilson Labs approached him about accepting the newly created position of vice president of engineering, Dietz hesitated. He had earlier designed a floppy exerciser for Wilson as a moonlighter. The flat fee he'd accepted for the project had proved less than lucrative for him—Dietz estimates he earned about $2 an hour on the project. He was not enthusiastic about doing any further work for the company.

Together, the two men devised an incentive attractive enough to lure Dietz into joining Wilson Labs full-time: cash royalties on products that Dietz designed or supervised. Neither had ever negotiated such an arrangement before. "It was brand new to both of us," Dietz says. "I think Randy was a little scared. But he knew it was the only way *he* could talk someone into coming on board."

Wilson staff members *(L to R) Jonathan Hanmann, Raymond Fung, Michael McCabe, Wilson, and Bill Postma.*

Competing for engineers

Wilson also sensed that extending a similar program to engineers was the solution to his problem of convincing them to join a company that they might otherwise perceive as just another California start-up. Royalties would carry more appeal than would stock options or profit sharing, because the royalties would be based only on the sales performance of the products each engineer designed, not on company-wide sales figures. The program would also provide an option for engineers who wanted to increase their income without moving into management.

A sense of altrusim, however, is not among the company's reasons for remunerating engineers. "This program is for my own benefit, so that I can keep top-quality engineers," Wilson says candidly. "I can't afford to spend time to get these people trained and then have another opportunity for them show up down the street." He says that the program has been effective in both attracting and retaining engineers.

Indeed, Wilson correctly guessed that if engineers had a vested interest in their work, they'd feel the same thrill that he'd felt when he'd started his own business. "Once you release a product, you don't forget about it," says hardware designer Michael McCabe. "You figure, 'If I improve the product, we'll ship more of them.'" Project leader and programmer Jonathan Hanmann adds, "You feel an involvement every time the product is sold. When changes have to be made, you feel more incentive to get things done as quickly as possible because it means more money."

Although Bill Postma has yet to receive any recompense from his work at Wilson, he prefers the royalty program to previous employers' bonus plans, which were based on the company's earnings. "It's hard to figure out how stock options and other bonus plans are going to pay off," says Postma, who joined the company in May. "The same thing holds with the royalty programs—you never really know if the product's going to be a winner. But I feel I can contribute more directly than I could to other plans. I like the concept because it ties more closely the individual and the work."

Once deliveries of a product begin, engineers receive monthly royalty payments—a carefully calculated interval. "The check coming every month is a nice reminder, a tickler to an engineer that through his efforts he sees this extra reward," says Wilson.

Contractual agreements

Inclusion in the royalty program is not automatic upon hiring. Each engineer is invited to participate in the program at the discretion of Dietz and Wilson. Both the company and the engineers are bound to the royalty agreements by contract. The contracts stipulate each engineer's percentage of the profits as well as a cap on those profits that ranges from $5000 to $50,000. Annual royalties paid to the company's engineers average $75,000.

> The royalty program has helped minimize the problems of poorly designed or late-to-market products that plague other companies.

Keeping the remuneration flexible is key to its success. The company's initial products employed little software, which meant one hardware engineer could bear nearly total responsibility for a product. Wilson hoped the program would give engineers a feeling of being in business for themselves. "To get his royalty, an engineer had to make sure the product worked," Wilson says. "He'd help work on the data sheets, talk to customers about the product and do a demonstration for them if they came in, and make sure the salesmen knew how to sell the product."

Now, however, software controls much of disk-drive testing. As a result, designing the equipment requires teams of engineers. The royalty contracts underscore the importance of a cohesive team: Payments depend on completion of a project according to timetables stipulated by the contracts. "Everyone's royalty is based on delivery of the [whole] product, not just their portion of it," says Wilson. As a result, "if one team member is falling behind, the other members are going to be concerned about it and try to shore up the guy."

The company's newest product line is also its most technically complex and put the program to its greatest test. Three hardware engineers and seven software programmers worked on the 7000 Series, a multiport test system based on the concept of distributed processing. Sales of the product should exceed $1.5 million by the end of the third quarter. Delivery begins in October.

Tension mounted last year when it appeared that difficulty in obtaining parts would make it impossible for the engineers to meet the deadlines specified in their contracts and jeopardize their ability to collect royalties. The deadlines were eventually revised. "If there's a component shortage, we're not going to hold people responsible for that," Wilson says.

Grass isn't always greener

Despite its successes, the royalty program is not without drawbacks. Wilson questions the staying power of a monthly financial incentive. "Once you start receiving regular checks, they become like salary," he says. "You can forget what the check represents, that we're providing it so you'll look at the situation as if you're in business for yourself." Potential problems also exist if the company decides to de-emphasize sales of one product in favor of another, thereby depressing the royalty checks of some engineers.

As the 7000 project revealed, royalties become more difficult to administer as the products increase in complexity and staff involvement. The more people there are involved in a project, the more divisions have to be made in the profits. Raymond Fung, chief scientist for Wilson Labs, joined the company six years ago, the second full-time engineer hired after Dietz. Says Fung: "As the company grows, I feel the program is less effective. Product design is no longer fully under your control."

Postma worries that the engineering staff could become preoccupied with profit to the detriment of the company's products. "One of my concerns here is that if there's a lot of emphasis on royalties, then we all become mercenaries," Postma says. The additional financial return is a nice benefit, he says, and was a consideration for him when he joined the company, but not his primary reason for doing so. Wilson Laboratories' small size (70 employees), the challenge of a management position, and a competitive salary were more important to him than the royalty program.

> Wilson correctly guessed that if engineers had a vested interest in their work, they'd feel the same thrill that he did when he started his own business.

Indeed, an important lesson learned by the company is that money is not the ultimate motivator. "To me it's compensation, not motivation," says Hanmann. The extra money's affect on his work is subtle, says the programmer. "I don't ever look at my work and think, 'Oh boy, there's all this money to be made.' You can't think that way in software. I do the work because I enjoy it."

Money also falls short of being a foolproof method for retaining employees. When one member of the engineering staff recently submitted his resignation, Dietz tried to talk him into staying by reminding him of the royalties he stood to receive. "I asked him, 'You're turning down $20,000 to $30,000 a year to do your own thing?' He said he had to, that the long-term potential [for his new pursuit] was much greater." Dietz was also surprised to find himself trying to talk one job candidate into accepting the royalty plan. "He doesn't want it," Dietz shrugs. The company is also well aware that royalty income does not absolve it from continuing to provide challenging technical work. "If it's not fun to come to work every day, why bother?" Dietz asks.

Breaking with tradition

Wilson's open discussion of engineers' earnings—a taboo subject on most corporate fronts—is atypical in the electronics industry. Even more unconventional is its willingness to share profits with them. "It's like talking about joining a union," Wilson says. "In a small company, an engineer can't walk in to a manager and say, 'Why can't I share in the profits?' The first thing they're going to say is 'we've got to replace this guy.'"

Such financial arrangements, though, "are an event waiting to happen," he says. "A privately held, independent company that wants to develop first-class products must have some tool to retain its staff." **EDN**

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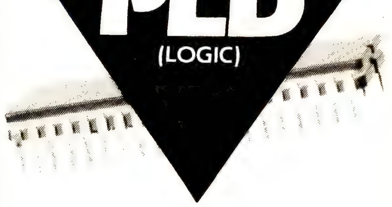

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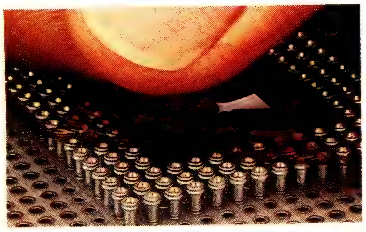

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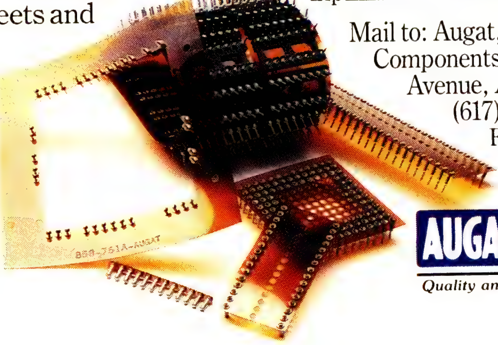

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Oct. 15	Sept. 24	Test & Measurement Special Issue; Analog ICs; ASICs	Closing: Sept. 17 Mailing: Oct. 8
Oct. 29	Oct. 8	Computers & Peripherals; ICs & Semiconductors; Wescon '87 Product Preview	
Nov. 12	Oct. 22	Wescon '87 Show Issue; ICs; Computers & Peripherals	Closing: Oct. 15 Mailing: Nov. 5
Nov. 26	Nov. 5	Microprocessor Technology Report & Directory; Analog ICs; Sensors & Transducers	
Dec. 10	Nov. 19	Product Showcase-Volume I; ICs and Semiconductors; Software	Closing: Nov. 12 Mailing: Dec. 3
Dec. 24	Dec. 3	Product Showcase-Volume II; Computers & Peripherals; Test & Measurement Instruments	

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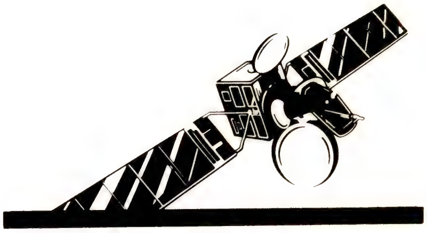

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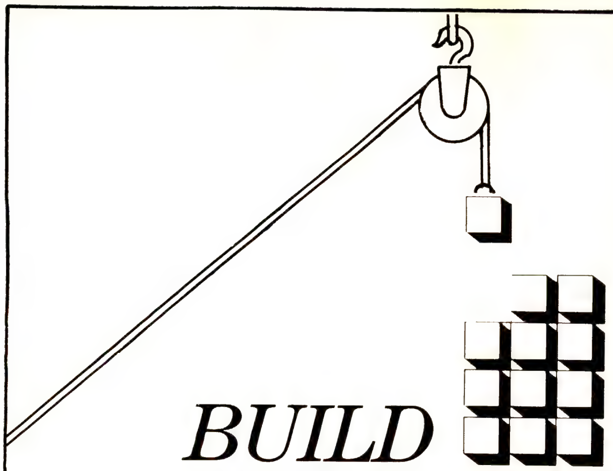

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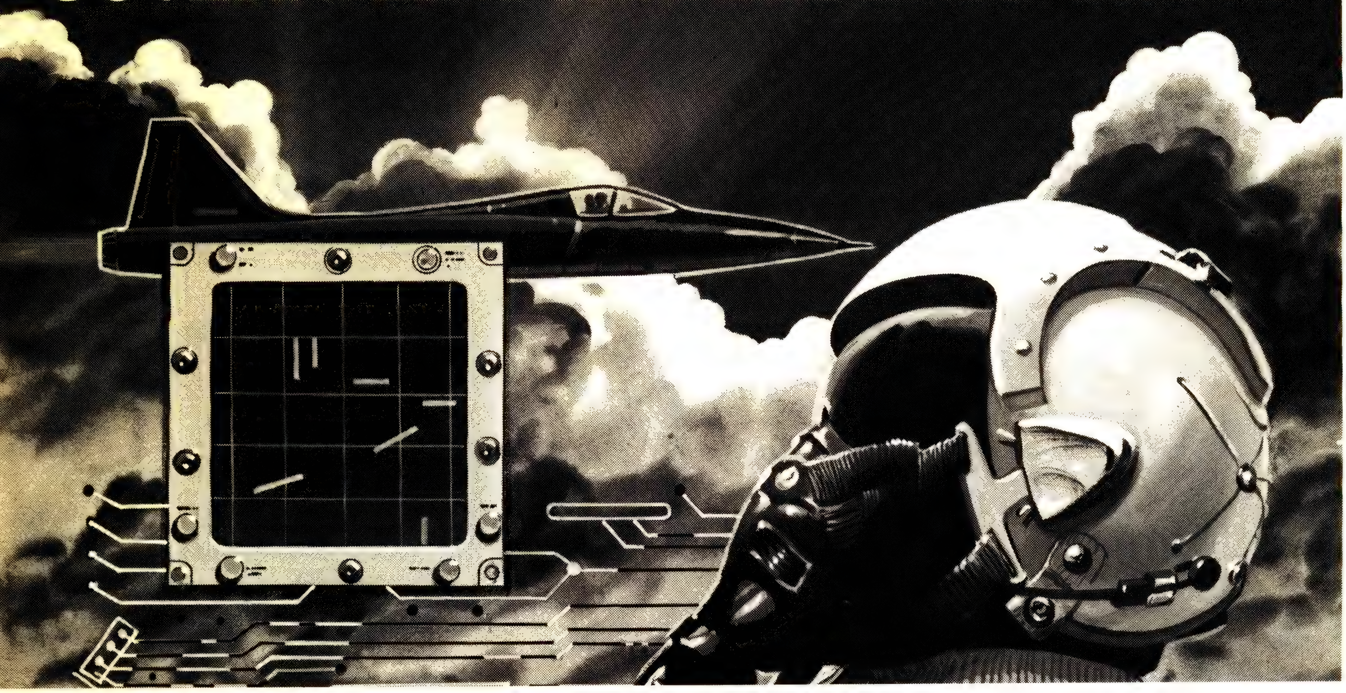

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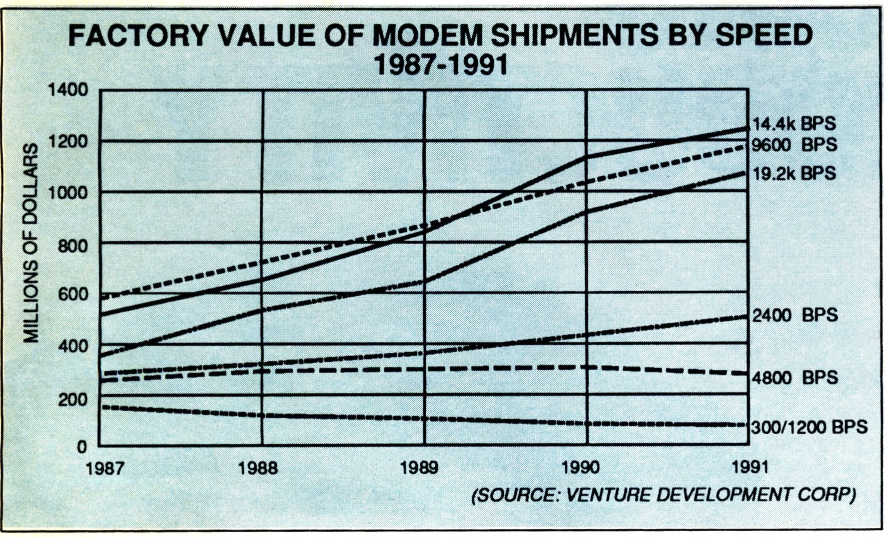
FACTORY VALUE OF MODEM SHIPMENTS BY SPEED 1987-1991

(SOURCE: VENTURE DEVELOPMENT CORP)

US modem shipments to double by 1991

The factory value of US modem shipments is expected to top $2 billion this year and to reach the $4 billion mark by 1991, according to Venture Development Corp (VDC), a management-consulting firm located in Natick, MA. The greatest growth will occur in the higher-speed models. Although these modems, which communicate at 9600 bps or faster, will constitute just 34% of the total units shipped in 1991, they will account for nearly 80% of the dollar value of devices shipped.

Medium-speed modems, which operate from 2400 to 4800 bps, will make up the core of the units shipped. Improving price/performance ratios will encourage owners of lower-speed modems to upgrade their equipment; such owners may also often take dramatic leaps from low-speed devices directly to 9600 bps modems. Companies that use PCs for communication sporadically, however, will continue to employ low-speed models, according to VDC.

The fast-growing popularity of direct-dial applications, together with the steady interest in leased-line applications, is benefiting the 9600-bps segment of the market. Very-high-speed modems, which operate at 14.4k and 19.2k bps, should experience rapid growth of annual shipments and also claim more of the dollar value of the market because of their much higher prices. In addition, these devices can be a sizable investment for the individual customer because they must be used in pairs, with one at each end of the communications line. They also require individualized configurations for each computer communications system. If improperly configured, a high-speed modem operates at much lower rates.

VDC notes that the benefits of using the highest speed modems are great. Obviously, users can deliver information more quickly, which is a significant advantage in organizations that require repeated transfers of computer files. Furthermore, timesharing costs are reduced and telephone connect charges are lower because less time is needed to send any given amount of data.

Next four years' growth gives SMT-assembly market shape

The domestic assembly of surface-mounted packages, which accounted for 12.1% of the total packaging market in 1986, will constitute between 30 and 40% of that market in 1991, according to CEERIS International Inc (Old Lyme, CT). Increasing volumes of assemblies will boost revenues for all types of packaging. Thus, through-hole technology will also grow but at the much slower rate of 3% annually on average.

The analysis divides component consumption and packaging trends into seven sectors: computers and office automation, telecommunications, instrumentation and industrial controls, avionics and defense, consumer products, automotive products, and subcontractors. CEERIS notes that ICs now make up 50% of the computer-industry component mix, but claim less than 7% of the automotive-electronics component mix. The impact of surface-mount technology varies according to the need for miniaturization, the need for increased function within a given design, and the ability to successfully complete the requirements of the surface-mount assembly process, which is far more stringent than are through-hole processes.

MARKET SHARES OF PACKAGING ASSEMBLIES BASED ON NUMBER OF UNITS

	1986	1991—GREY SCENARIO	1991—ROSY SCENARIO
THROUGH-HOLE ASSEMBLY	87.9%	69.5%	58.5%
SURFACE-MOUNT ASSEMBLY—AUTOMOTIVE	9.2%	11.9%	12.0%
SURFACE-MOUNT ASSEMBLY—NON-AUTOMOTIVE	2.9%	18.6%	29.5%

(SOURCE: CEERIS INTERNATIONAL INC)

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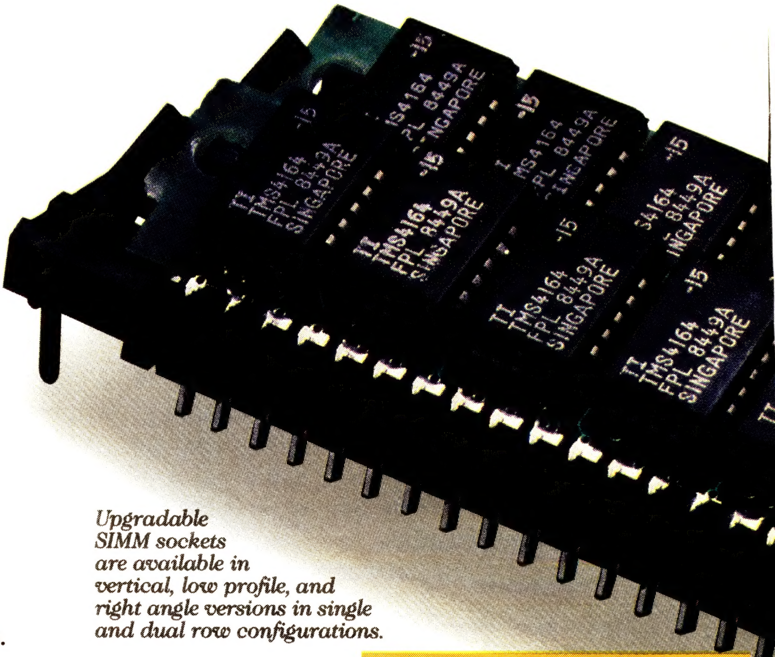

Upgradable SIMM sockets are available in vertical, low profile, and right angle versions in single and dual row configurations.

From through-hole technology to surface-mount technology, Molex makes the connection.

Molex is working to help today's manufacturers develop SMT products that utilize less space and assemble with greater efficiency. Components such as our SIMM sockets are currently helping major manufacturers utilize innovative SIP technology to achieve denser circuit board packaging and increased RAM capacity. And, systems such as our automated robotic PCB assembly equipment are speeding production time and reducing labor costs.

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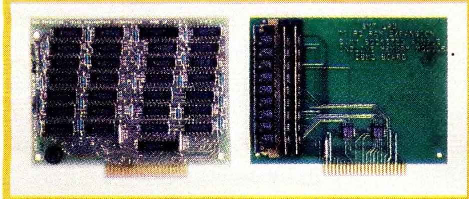
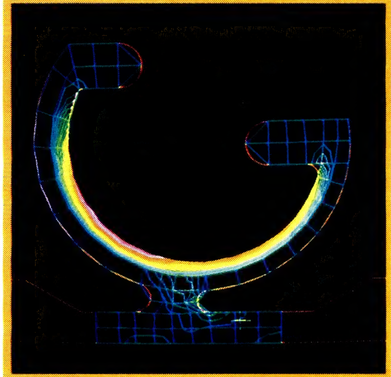


Molex SIMM socket (right) takes up dramatically less board space than DIP packaging (left).



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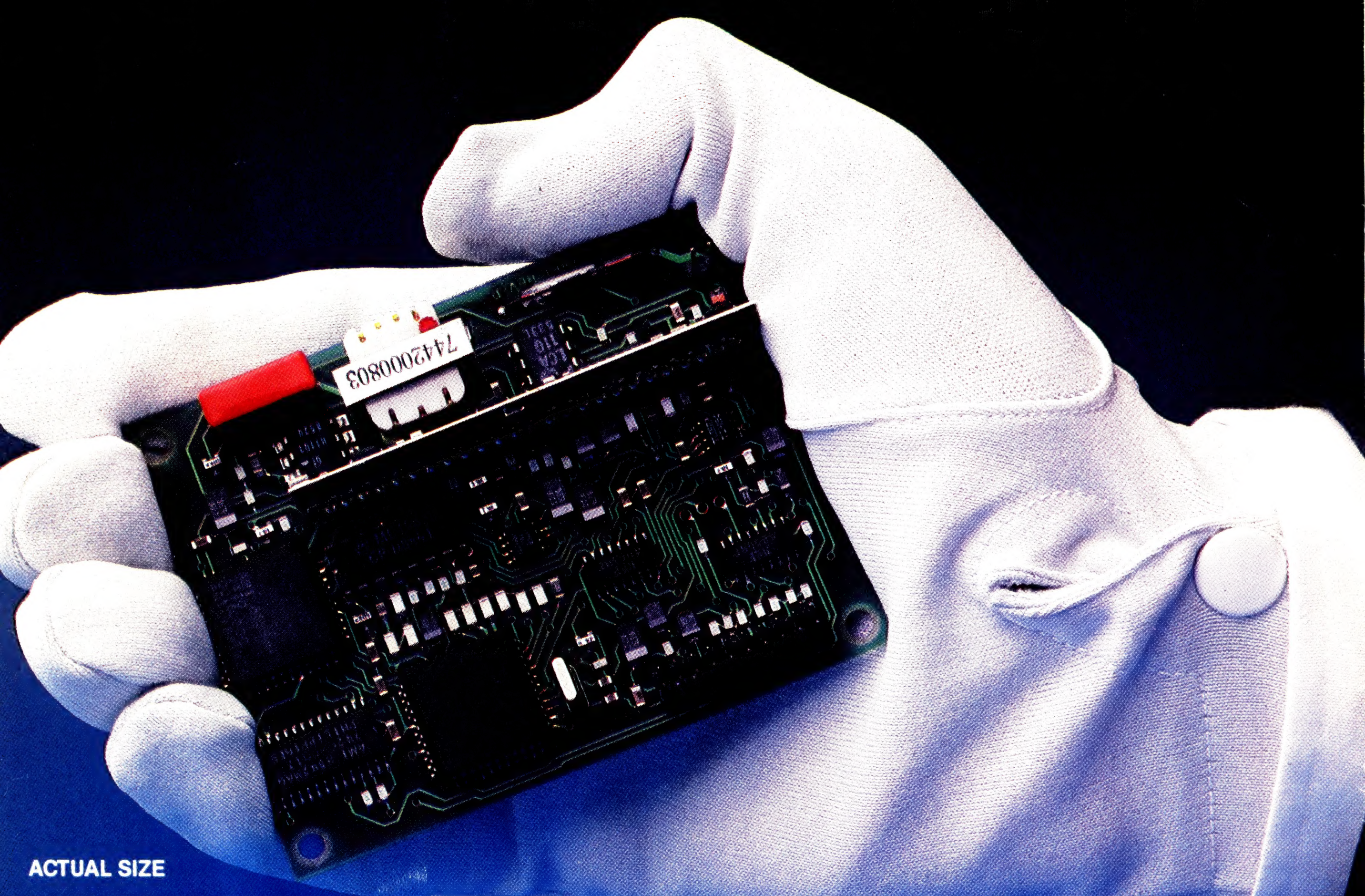

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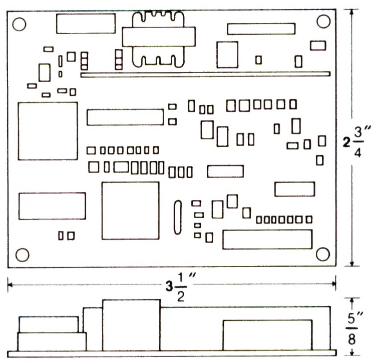

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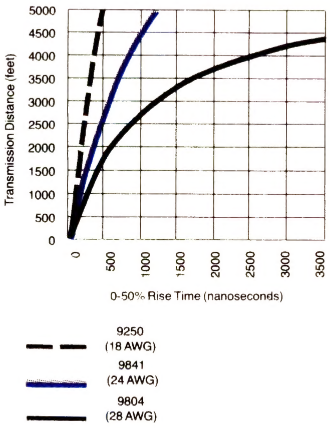
Belden® Extended Distance Data Cables provide faster data rates over longer distances, while maintaining signal integrity. Whatever your system needs, Belden data cables help you achieve the highest possible levels of performance.

Settling a bit of confusion.
In general, it's true that low capacitance contributes to a better computer cable. At higher bit rates, however, the cable selection process becomes dependent on other cable parameters such as signal rise time, impedance matching, attenuation and shielding.

If data speed and distance set limits of superior performance for your computer system, "low capacitance" alone can no longer define your performance requirements. You need the sophistication of fast rise time and advanced shielding technology in a cable matched to your exact requirements.

Approach the Speed of Light with Extended Distance Data Cables from Belden.

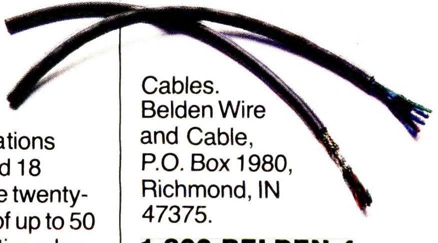
Rise time and distance dependency on wire gage.



Comprehensive selection to meet every need.
At Belden, we'll assist you with the selection of data cables at the onset of your design, helping avoid costly overdesigns. Belden offers a wide selection of data cables in multi-conductor and twisted-pair configurations with 28, 24, 22, 20 and 18 AWG sizes. There are twenty-six multipair options of up to 50 pairs, and fifteen multiconductor options of up to 50 conductors. Overall foil, individual foil, braid, and overall foil/braid shields are available, as are a variety of insulations to meet your requirements.

Belden's selection of Datalene®, polypropylene, polyethylene, and semi-rigid PVC insulations provide capacitance levels ranging from 11 pF/ft. to 35 pF/ft.

For extended distance and optimal signal performance in data cables, look to Belden; *There is no equal.*™ Write or call for your free brochure detailing Belden's comprehensive line of Extended Distance Data Cables.



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47375.

1-800-BELDEN-4
In Indiana call
317-983-5200

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CIRCLE NO 223

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